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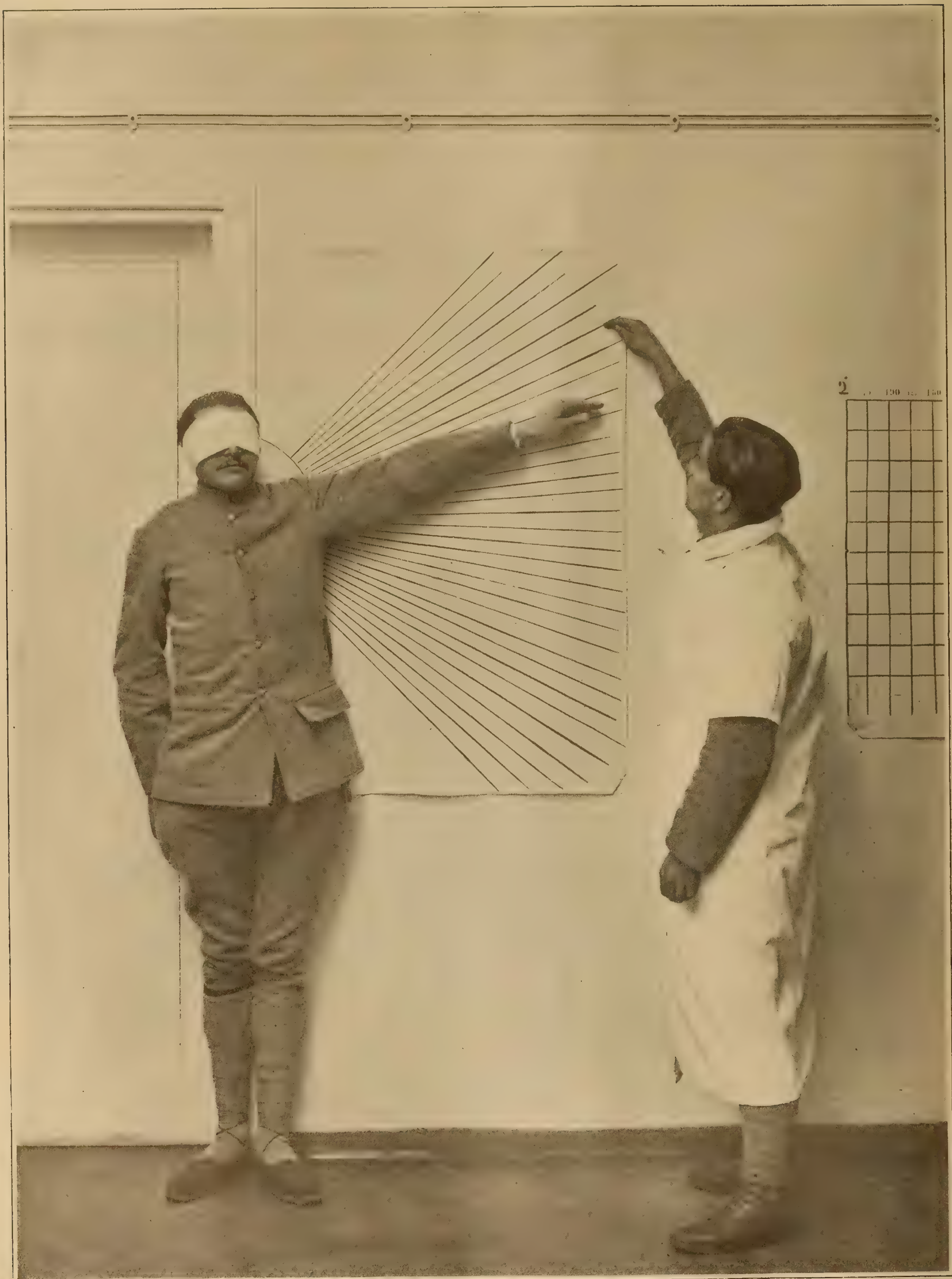

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HALF A MILLION HORSEPOWER FROM THE TIDES

WE have been wont to look upon solar heat as the original source of all available power on earth. Fuels are unquestionably stored solar heat energy, while water power and wind power also have their origin in the same source. Wave power is really disguised wind power and that, too, is attributable to the heat which the sun pours upon this planet.

There is another form of power, however, of which the sun contributes only a minor part: the chief contributor being the moon. Tidal power is in a very different class from all other powers in the fact that heat plays no part in its generation. Such use as has been made of the power of the tides is so insignificant as to be hardly worth recording.

Tidal power is so widely diffused that in most localities it is hardly worth utilizing; or else it calls for engineering construction of a discouragingly vast extent. One of the most serious draw-backs to the development of tidal power lies in the fact that the ebb and flow follows a lunar schedule while the inhabitants of this planet regulate their habits by the apparent diurnal revolution of the sun. Our power plants have to carry a heavy load in the day time to furnish power for industrial purposes and there is another heavy peak load in the evening when the public uses artificial light to prolong the day. Unfortunately a tidal power plant cannot adapt itself to existing requirements, but must operate under a hydraulic head that is ever varying rhythmically between zero and maximum. Being regulated by the moon instead of the sun this peak of power output is just as likely to come at a moment when we sun-regulated humans least need it, and, on the other hand, when our demands for power reach a maximum the tidal plant may not be turning a wheel. Obviously, to be at all successful, the plant must be provided with means whereby surplus energy, developed at ebb-tide may be stored temporarily and delivered later, thereby giving a constant output regulated in accordance with the demand. The most practical and economical storing system consists in pumping water into a reservoir from which the water may be fed back, as required, to drive an auxiliary plant that will supplement the tidal plant.

There has been much theorizing about the development of tidal power, particularly in these days when the cost of coal is high and we begin to realize, as we never did before, that our stores of fossilized fuel cannot last forever. Vast engineering enterprises have been proposed, such as damming the English channel and creating tidal reservoirs along the shores of England and France. These schemes have appealed to the imagination, but we have been wont to look upon them as the extravagant dreams of visionaries. It is therefore with a shock of surprise that we read of a real tidal power scheme of vast proportions actually formulated and fathered by the Civil Engineering Department of British Ministry of Transport. It is proposed to throw a dam across the Severn River about in line with the Severn Tunnel. The Severn at this point has a rise of thirty feet at the time of the spring tides. What the average rise may be, we are not informed. The water as it rises will be let in through the dam and on the ebb-tide will flow back through turbines which will begin operating when there is a head of about five feet. The ebb-tide on the Severn occupies a longer period than the flood-tide and it is estimated that there will be a working period of about seven hours followed by about five hours of idleness. The turbines will generate about half a million horsepower per ten-hour day with a peak output of approximately one million horsepower. About ten miles from the dam a great reservoir will be constructed near the River Wye which runs into the Severn. On the banks of the tidal portion of the Wye River a large pump and power plant will be erected, and surplus power generated by the Severn plant will be used to drive centrifugal pumps at the Wye plant. These pumps will deliver water to the reservoir, which will be located at a high level. Details have not reached us as to the height of the reservoir or its capacity, but it will certainly be of goodly proportions because the water is to be fed to it through a tunnel forty feet in diameter. This tunnel is to be driven through solid rock for a distance of more than a mile. The motors for driving the centrifugal pumps will be arranged to serve as generators when water is fed back from the reservoir. The power of the tidal plant, which is employed in pumping water into the high reservoir, will all be given back except for such losses as are due to the pumping machinery employed and to the friction of the water itself.

It is planned to generate about five hundred thousand horsepower at the Wye plant so that there will be a continuous output of approximately half a million horsepower. This will make the Severn Tidal Plant the largest plant in the world. At Niagara Falls, 675,000 horsepower is now being developed, but this is distributed among a number of different plants on both sides of the river. The Severn should become as large an industrial center as Niagara is today. If more power is generated than can be used in the immediate vicinity of the plant, it can be easily transmitted to more distant localities; in fact it is quite possible that a large portion of the power produced will be stepped up to a high voltage and transmitted as far as London. On the basis of four pounds of coal per horsepower it requires over seventeen tons of coal to produce one horsepower per year, consequently the proposed plant when complete should effect an annual saving of eight and a half million tons of coal.

According to a statement recently made in Parliament the construction of this plant will give employment to ten thousand men for a period of seven years.

The Limits of the Universe*

Recent Researches Which Have Extended Our Concept of the Star-Filled Heavens

By Dr. Svante Arrhenius

President of the Nobel Institute of Physical Chemistry at Stockholm

IN ancient times man believed that our Earth was the center of the Universe and that the starry heavens made a diurnal revolution about it. The great mass of the world was supposed to be constituted of the known parts of the earth and universal space was accordingly very limited. This idea was overthrown by Copernicus, according to whom the Earth, like other planets, describes a very long path about the Sun, while the fixed stars lie outside the solar system. But universal space has acquired far greater dimensions than the men of old ever dreamed of.

According to the Copernican concept, however, the fixed stars apparently were obliged to change their place in the heavens in proportion as the Earth described her orbit. By means of this motion, whose magnitudes were termed parallaxes, it ought to be possible to ascertain the distances of the fixed stars. But Tycho Brahe sought in vain to measure the parallaxes of the stars and found them immeasurably small. It was accordingly supposed by him that either the fixed stars must be immeasurably remote from us or else the earth must be stationary. Tycho Brahe found the second alternative to be the more plausible and, therefore, replaced the Earth in its former position as the center of the universe.

But the majority of the astronomers refused to accept Tycho's reasoning and tried all the harder to measure the parallaxes of the stars. But no one was successful in this until a quarter of a millennium later when Bessel accomplished the feat in 1838 when he discovered a parallax of 0.3 arc-seconds for the star 61 in Cygnus, according to which this star is located at the enormous distance from the sun of 10 light-years or 100 billion kilometers. In the following year Henderson found in Kapstadt that the brilliant star Alpha Centauris is much nearer to us; its parallax was found to resemble an arc-second corresponding to 3.25 light-years, a figure which was later corrected to 4.5 light-years, corresponding to a parallax of 0.75 arc-seconds.

These successful achievements were rightly regarded as a triumph for the science of astronomy. By means of these the measured distances of universal space were estimated to be 100 thousand times greater than those of the solar system whose diameter like that of the orbit of Neptune consists of about 9,000 million kilometers. For it is possible to measure with considerable practical precision stellar distances of cc. 100 light-years. Astronomers busied themselves hereupon in measuring in this manner the stellar universe in every direction. The first great enthusiasm was gradually followed, however, by a certain amount of disillusion. It soon became evident that the star-filled space was far too immense for it to be feasible measure it by the known methods of geometry. It was found, too, that not even a complete thousand among the billions of celestial candles were susceptible of having their location in space determined. The most distant stars in the Milky Way are at far too great a distance to be determined. Thus, for example, the distance of the star cloud in Cygnus is estimated at cc. 25,000 light-years and that of the small Magellanic cloud at cc. 6,000 light-years.

It was necessary, therefore, to invent another method of representing these vast gulfs of space. The great scientist, William Herschel, made statistical measurements of the number of stars in the system of the Milky Way, and was thus led to embrace the view that this system lies within a lens-shaped section of space whose greatest diameter is 850 times that of the average distance of a star of the first magnitude and whose width is only 1/5.5 as great. However, since we cannot determine the aforesaid average distance this estimate is rather indefinite. The celebrated astronomer, Seeliger, has endeavored in recent years to obtain a concept of this expanse by means of a very thorough mathematical handling of the statistical material concerning the star density in the Galaxy. He found that assuming certain hypotheses to be true, its greatest diameter is apparently equal to 50,000 light-years and its smallest diameter to about 10,000 light-years.

Although these calculations are rendered extremely uncertain because of the aforesaid assumed hypotheses, yet they represent a great step in advance with respect to the earlier calculations, among which may be mentioned those of the great physicist, Lord Kelvin, and the distinguished Heidelberg astronomer, Max Wolf, and which result in a computed length of 6,000 to 40,000 light-years for the greatest diameter of the Galaxy.

In any case, however, the majority of astronomers were inclined to believe that the stellar universe is confined to a certain limited extent of space, corresponding roughly to that occupied by the Milky Way. In their view the Sun occupied a comparatively central position within this limited system. In this manner it was possible to agree with Wallace in his view that we might still cling to a fragment of the ancient orthodox Aristotelian theory that man occupies a preferred position in the universe.

Some students of the matter, however, were dissatisfied with these narrow views which rest upon the incompleteness of the determination of the parallaxes, and they, therefore, sought new methods of determining the distances of the heavenly bodies. It was, in fact, determined by a series of measurements that the Sun moves among the swarm of stars with a velocity of cc. 20 km. per second in the direction of Hercules. If the stars were standing still, it would be quite easy, of course, to determine their distances by means of their *apparent* movements resulting from the motion of the sun.

If we take into consideration, however, a very large number of stars it is probably safe to assume that they are standing still on the average. In this manner a number of astronomers and, particularly, the famous Hollander, Kapteyn, have ascertained the average distance of various systems of stars and have obtained very interesting results.

It would be far more instructive, however, if we were able to ascertain the distance of the individual stars. For this purpose a method has been employed which has been used for unknown ages to determine distances from the earth. When we know the size of an object, e. g., of a house, a tree, or a man, and either measure or estimate the angle formed by this object with the line of vision, it is possible to estimate the distance of the said object. For example, the distance of a given man is estimated in this manner as a military exercise. Applied to the stars the method is employed as follows:

We assume that all the stars of the same system possess equal magnitudes, and that their surfaces are likewise equally luminous. It follows from this that a star belonging to a system located at a distance of 20 light-years is only ¼ as brilliant as a similar star at a distance of ten light-years. But the comparative intensity of the light of a star can readily be determined, partly by observation with the eye, in which case it is compared with the luminous intensity of some nearby star which has already been measured, and partly also from the *blackening of a photographic plate caused by the image of the said star*, in which case the said image is likewise compared with that of a known star recorded upon the same

* Translated for the SCIENTIFIC AMERICAN MONTHLY from *Die Umschau* (Frankfurt) for September 25, 1920.

plate. These two methods of determining luminosity do not yield the same figures, since *the redder (or colder) a star is the smaller its photographic luminosity compared with its visual luminosity.* This difference between visual and photographic brightness plays a great rôle in astronomy as we shall see, and it has, therefore, been given a name of its own, i. e., the *color index.* In the case of the white hydrogen-stars which are listed in the catalogue of the Harvard Observatory at Cambridge, Mass., under the sign A_0 the color index is O; in the case of the red star, the M. star of the same catalog, it corresponds to two classes of magnitudes.

When now it happens that a few such stars lie sufficiently near us for their parallaxes to be determined, so that their distance in light-years is known, then the distance of the others can be computed from the intensity of their luminosity, since the latter is proportional to the square of the distance. It was in this manner that Charlier computed the distance of the Helium Stars which are listed in Harvard Catalog under the letter B from a provisional investigation by means of the Kapteyn method. The result was, however, that these must be divided into two subordinate groups, one of which is designated with the letters B_1 and B_2 while the others are listed under B_0, B_3, and B_5 in the Harvard Catalog. As a result of the Charlier researches it was discovered that these groups of Helium Stars form an exceedingly limited collection, which is strongly concentrated about the plane of the Milky Way and whose middle point lies at a distance of about 320 light-years from us and whose greatest diameter is about ten times as large. They are enclosed between two planes, which lie at a distance of about 1,000 light-years apart from each other. This group forms a cluster of stars having about the same dimensions as those of the Milky Way as computed by Kelvin. Charlier was also of the opinion that this formation is to be regarded as a sort of skeleton of the system of the Milky Way. However, the Milky Way is far greater in extent, as has been proved by later investigators, and the Helium Star groups of Charlier are now commonly called "the local star groups." Our own Sun and the overwhelming majority of the visible stars lie within this group.

A very admirable *method of determining the absolute magnitude of a star* and thereby of finding its distance, since the magnitude seen by us is known, was invented in 1917 by Adams at the Mount Wilson Observatory. He investigated the relative intensity of certain lines of the spectrum and the absolute luminous intensity of about 100 stars, whose distances are known to us exactly. He found that the *absolute luminous intensity* of these stars can be computed with great exactness from the behavior of the *lines of the spectra* examined. In this manner it is possible to calculate the absolute luminous intensity of a star whose distance cannot be determined by means of the measurement of the parallax, and thus the distance can readily be computed. This Adams method is not adapted, however, for application to the white stars or to stars which are fainter than those of the tenth magnitude. Dr. Lindblad of Upsala has suggested a modification of this method in which the location of the maximum of luminosity in the normal spectrum of the star in question, and the location of the extreme ultra-violet portion of the spectrum are determined. By the aid of this adapted method it has been possible to determine the distance of stars even as remote as the seventeenth magnitude, although the degree of precision is not so great as in the Adams method. By means of this method the distances of the star-nebulae which belong to the Milky Way have been measured. Thus, for example, the stellar nebula in Auriga has found to be at a distance from us of about 5,000 light-years, that in Cygnus at about the same distance, and that in Aquila at about 17,000 light-years. According to this the Milky Way presumably forms an immense spiral with a diameter of from 50 to 100 thousand light-years.

Since the earliest historical times the attention of human beings has been strongly attracted by certain so-called *open star clusters,* such as the Pleiades and the Hyades. From the movements of these star clusters Kapteyn calculated their distance at from 220 to 130 light-years. Shapely, whose researches in this domain are of extraordinary value calculated by means of the Adams method, the position of 70 such clusters and found that the two which are nearest to us are the aforesaid Hyades and Pleiades, which form an exception in that the cluster which follows them in Dreyer's New General Catalog, No. 3532, is at a distance of 1300 light-years from us. It lies only 32 light-years to the north of the middle plane of the Milky Way. The farthest from us of these celestial objects bears the number 6005 in the above catalog and lies at a distance of about 55,000 light-years from us and of only 3600 light-years to the south of the middle plane of the Galaxy. These researches have led to the conclusion that these formations lie closely crowded about this middle plane. Hence they undoubtedly belong to the Milky Way, and their diameter is, according to these measurements, of about the same magnitude, i. e., about 100,000 light-years as was obtained from the calculation of the distances of the stellar nebulae. Hence the system of the Milky Way is according to this about thirty times as great an extent as the local star cluster of the helium stars.

A still greater sensation was produced by Shapley's measurements of the distances of the changeable stars, which have obtained the name of Cepheides from the star Delta Cephei as well as of the enormous masses of stars which have received the names of globular or closed star clusters. Shapley discovered that the redder the color of one of the Cepheides and the longer the period of its alternation of light, the greater its luminous intensity. With the help of these two circumstances he was able to ascertain the absolute luminous intensity and likewise the distance of these marvellous stars. He found it convenient to divide them into two principal classes according to whether their period is more than 24 hours or less. Those having the long periods are giant stars, whose absolute luminous intensity is from 200 times to 10,000 times as great as that of the Sun. Their movement in the direction of the line of vision can be measured as we know by means of the spectroscope. It averages less than 10 km. per second. They are massed very densely in the vicinity of the middle plane of the Milky Way. They evidently belong to the system of the latter and lie comparatively near us—the farthest one known to us being at a distance of cc. 20,000 light-years.

The Cepheides having short periods lie at about the same distance, but they are distributed in an almost uniform manner around the Sun. Those few among them, only four, whose velocity we have thus far been able to determine, are *rushing,* according to Adam's measurements, *with furious rapidity through celestial space.* Their velocity in the line of vision varies from 52 km. to 196 km. per second. Their luminous intensity is on the average "only" a little bit more than 100 times as much as that of our own Sun. Even these fainter stars among the Cepheides unquestionably belong to the Milky Way.

The Cepheides possessed a peculiar interest for Shapley because of the fact that such stars are found in the singular globular star clusters which often contain millions of stars, and which, to judge from the luminous intensity of these lie at a great distance from us. The various Cepheides found in the same star clusters have an almost equal power of illumination, whereas this is very different, on the contrary, in other star clusters. This is naturally due to the fact that the star clusters do not all lie equally near to us. By the aid of the Cepheides, Shapley determined the distance of those star clusters in which such variability occur. For this purpose he made use only of those having a period of less than 24 hours. Since, however, such stars do not occur in very many star clusters, he compared the power of illumination of the brightest non-variable stars with that of the Cepheides in those star clusters where they are present. He found that the former possesses upon the average 3.53 times as great a power of

illumination as the latter. By the aid of this figure he was able, therefore, to calculate also the distance of those clusters which contain no Cepheides. He made use of yet a third method, according to which he assumed that all star clusters having the same cluster diameter possess about 65 light-years. The results obtained by these three methods coincided admirably.

The globular star clusters form a system whose greatest diameter is, at least, 300,000 light-years, and whose middle point is about 65,000 light-years distant from the Sun. The one nearest to us, Omega in the Centaur, lies at a distance of 23,000 light-years from us, while the farthest which is number 7006 in the New General Catalog, is 220,000 light-years distant. These clusters are located symmetrically around the middle plane of the Milky Way, so that they are very seldom to be found in the neighborhood of the Galactic Pole. It is a remarkable fact that they are almost entirely lacking between two planes which lie at a distance of 6,000 light-years from the middle plane of the Milky Way. This has led Shapley to conclude that they possess a genetic connection with our own Milky Way system. As a general thing they are moving toward us (this being found to be true in seven out of ten cases which have been studied) with an enormous velocity which averages about 144 km. per second. Two of them are traveling away from us, one at a rate of 225 km. per second and the other at 10 km. per second. One of them possesses so slight a motion, as compared with ourselves, that it is to be regarded as practically stationary.

Charlier has assumed that since the globular star clusters are located in the vicinity of the Milky Way, they must belong to the latter, and is of opinion, therefore, that they lie at the same comparatively small distance from us, as do the helium stars studied by him, i. e., at less than 2,000 light-years, whereas, according to Shapley their distance is 100 times as great. Such a disagreement as this between two learned doctors caused astronomers to welcome a new calculation of this magnitude. This was made by Dr. Lundmark, in Upsala, partly by the application of other bases of calculation than those employed by Shapley. He found Shapley's results completely confirmed.

But Lundmark did not content himself with the confirmation thus obtained. He went a step further and sought to determine the *distance of the spiral nebulae* which are crowded most densely about the pole of the Milky Way. He took as a starting point the new stars which have appeared in some of these clusters, especially the most beautiful among them, the long known Andromeda Nebula. He compared the luminous intensity of these with that of the brightest of the "new stars" in the Milky Way, concerning which he assumed by reason of certain known facts, that they are upon the average as far distant as are the stars of the thirteenth magnitude. In this manner he found the distance of the nebula of Andromeda to be about 600,000 light-years. According to this its diameter would be 20,000 light-years, or about seven times as great as that of the local group of B stars. The Magellan nebulae would, according to this, also be nebular structures lying much nearer to us, namely, at a distance of about 60,000 light-years. Their diameters are two to three times as great as that of the local group.

But Lundmark has proceeded further still, starting with the assumption that other visible nebulae are approximately of the same magnitude as the nebula of Andromeda. This leads him to the conclusion that the average distance of these *nebulae* observed by him attains upon the average *the dizzy figure of about twenty million light-years.*

Lundmark found a few single stars standing out conspicuously in the Andromeda Nebula and in the magnificent nebula marked No. 33 in Messier's Catalog (in the star cluster of Triangulum). Assuming that these stars are as brightly luminous as those which exhibit the greatest luminous intensity in the Galaxy, he calculated that the distances of the aforesaid formation must be about 500,000 and 1,600,000 light-years. The first named figure agrees admirably with the one cited above for the nebula of Andromeda. Hence we are justified in concluding that Lundmark's calculations must be approximately correct.

By means of these recent researches our human concept of the star-filled heavens is vastly extended afresh as it was at the beginning of modern times by the genius of Copernicus. The development of the science has been so tremendously rapid in the 20th century, and especially in the last five years, that we can but expect that many details are subject to alteration and that others are yet to be discovered, by means of which the already proud results of these researches will gain in perfection and in beauty.

Infinity is, indeed, immeasurable, so that we shall never be able to prove definitely that the *universe is infinite in space as well as in mass,* but the millions of years of light-years with which our vision has been so suddenly enriched, would indicate that *no bounds are set to the spirit of research, except those which are involved in the imperfection of our tools.*

RECENT STUDIES OF THE MILKY WAY

THE always fascinating subject of the Milky Way has been the subject of fresh research during the last few months and some interesting discoveries are announced as a result thereof. The well-known Swedish astronomer, C. V. L. Charlier, in an address delivered before the Physical Society in Copenhagen, Denmark, in December, 1920, referred to some extremely important research being done concerning the Galaxy at the Lund Observatory. The work now in progress is based on a star map worked out by Prof. Wm. H. Pickering of this country and the English astronomer, Franklin Adone.

According to a special cable published in the New York *Times* of December 14, 1920, Prof. Charlier declares the work is already so far advanced that it is possible to state definitely that when it is completed it will be demonstrated that the sun is situated at one end of the Milky Way instead of in the center as has been heretofore supposed. It will be proved furthermore that instead of having a lenticular form the Milky Way is an ellipse whose major axis is directed toward the constellation Sagittarius.

Meanwhile the spectrum of the Milky Way has been the subject of special study in this country. While knowledge of the spectral type and motion of all the stars found in the Milky Way is today regarded as having an important bearing on the general study of our sidereal system the magnitude of the task of acquiring such comprehensive knowledge is somewhat appalling. It is quite possible, however, to obtain information concerning the predominant spectral type of the integrated light of the stars by treating the Galaxy as a luminous surface. For this purpose a spectrograph alone is sufficient.

Mr. V. M. Slipher read a paper upon this topic before the twenty-third meeting of the American Astronomical Society, a report of which we find in *Popular Astronomy* for December, 1919. He states that some preliminary observation along this line have been made at Flagstaff, Arizona. In these use was made of a spectrograph having a high light-power and sufficient dispersion to show plainly the chief features of the various spectral types. Observations of two regions were made—one in Sagittarius and one in Scutum—and lantern slides of the results were exhibited.

The spectra of the two regions were found to be similar, both showing in a very marked manner the main features of the solar type spectrum. However, it is revealed upon closer inspection that there are present stronger hydrogen lines than belong to the said type. Hence the spectrum would be termed "composite" with a predominance of the solar light. As a matter of fact, this result has been the cause of some surprise since studies of the brighter stars had given rise to the idea that the fainter stars of the Milky Way were of the first type. This result is in accord with that of Fath, who found the spectrum to be approximately of the solar type.

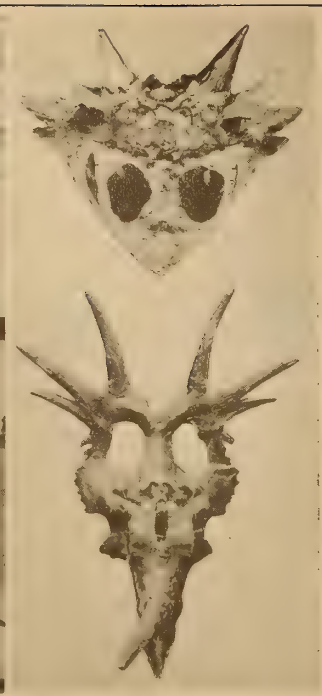


FIG. 1, SKELETON OF THE HORNED DINOSAUR *TRICERATOPS* NOW ON EXHIBITION AT THE NATIONAL MUSEUM. AT THE RIGHT, FIG. 2, A COMPARISON OF THE SKULL OF A HORNED TOAD (ABOVE) AND A HORNED DINOSAUR, *STYRACOSAURUS* (BELOW).

A New Horned Dinosaur from Canada

The *Styracosaurus Albertensis* with a Six-Foot Skull Bristling with Horns

By Charles W. Gilmore

Associate Curator, U. S. National Museum, Washington, D. C.

THERE has been discovered in the breaks along the Red Deer River in the Province of Alberta, Canada, the most remarkable example of an extinct Horned Dinosaur that has yet been brought to the attention of science. *Styracosaurus albertensis* as this animal has been called by the late Mr. L. M. Lambe, Chief Paleontologist of the Geological Survey of Canada, is known only from the skull, as the other parts of the skeleton were destroyed before the skull was discovered.

The skull of *Styracosaurus* is over six feet long with a great horn above the center of the nose that is nearly twenty inches high and six inches in diameter at the base. Most striking, however, is the development of six horn cores that radiate from the crest of the skull, as shown in Fig. 2, a top view of the head, which at its broadest part measures four and one-half feet across. The central pair of horn cores, which are the largest, are twenty-two inches long, the next pair twenty and the outer pair fourteen inches, respectively. In life all of these horn cores were covered with a horny skin, which probably somewhat increased their length. The name *Styracosaurus* is in reference to these bony spikes which must have made this reptile a veritable moving *chevaux de frise*.

Horned dinosaurs so far as known at the present time are only found in North America, and it was in 1887 that the first specimen consisting of a pair of large horn cores was uncovered in making an excavation in the suburbs of Denver, Colorado, and these so resembled the horns of the extinct bison that Prof. O. C. Marsh in writing of the discovery gave it the name of *Bison alticornis*, but two years later the discovery of complete skulls having similar horn cores showed it to be a reptile instead of a bison much to the discomfiture of the professor. This specimen is now preserved in the collections of the National Museum in Washington. It was the first of a long series of discoveries which through scientific and popular descriptions have made the horned dinosaurs familiar to the world. Although many different kinds of these horned reptiles are known the Canadian specimen tops them all in the ornateness of its skull decorations.

In Fig. 3 is shown a restoration of the head of *Styracosaurus*, based on the skull which was modeled by the author and depicts his conception of the probable life appearance of this animal.

There is a mistaken notion that extinct animals and especially the dinosaurs have a corner on all that is unusual in size and grotesqueness of form. In the matter of size the dinosaurs such as the huge *Brontosaurus* and its allies were the largest land animals the world has ever known, but in bulk probably none of these exceeded in weight the whales of the present day. In the matter of appearance it must be borne in mind that many of the striking peculiarities of the dinosaurs are enhanced by their great size and this is true of *Styracosaurus*, for when the skull of this animal is compared with that of the living "horned toad" (*Phrynosoma*), see Fig. 2, which by the way is not a toad at all but a lizard, a striking resemblance is to be observed. This resemblance is not so much in the shape of the skulls as in the similarity of their horny decorations. Should the skull of *Phrynosoma* be enlarged 72 times, for it is only an inch long, in order to bring it up to the same size as the *Styracosaurus* skull it would be even more bizarre in its appearance than the head of that animal.

The discovery of this fossil specimen by Mr. Charles H. Sternberg is interestingly told in his book, "Hunting Dinosaurs on Red Deer River, Alberta, Canada." He says: "On the 19th of September I made the discovery of the strange spiked dinosaur, called by Mr. Lambe *Styracosaurus*. The ground was wet with repeated showers. The fossil beds are not safe then, as one slips as if walking on soft soap. There is much clay in all the rocks; in fact more than half of them

are made up of clay, interlaid with silver gray sandstone, also containing much clay. However, I could not idle about camp and made the attempt to get in the badlands, walking up the bed of a long coulee that was filled with boulders. I got to where it was extremely difficult, as the bed was narrow and crooked, but at last reached the head. Many other ravines headed near by, and in going over to one of them I saw in the steep slope of a narrow gorge, in gray sandstone, the skull that is shown in Fig. 2. It was 200 feet below the prairie, and it required a great deal of labor to collect and load it in the wagon. It was packed securely in a box, after it had been carefully wrapped in burlap dipped in plaster, and secured with strong poles to hold it together. A road was cut in the face of the cliff, and our faithful team hauled the box weighing about nine hundred pounds out of the ravine; they often fell down and cut themselves, but they scrambled up the narrow road with their burden fastened to a sled. When they got to the level prairie the boys let the hind wheels into the ground to the hubs and rolled the box in. The skull was partially prepared by me the next winter."

This specimen now forms an interesting part of the exhibit of fossils in the Victoria Memorial Museum in Ottawa, Canada. Although as yet nothing is known of the body part of the skeleton there is every reason for believing that when found it will resemble in form and bulky proportions the mounted skeleton of the horned dinosaur Triceratops now exhibited in the United States National Museum as shown in the illustration (Fig. 1). This specimen with a skull six and one-half feet long measures about twenty feet in length over all, and stands about eight feet high at the hips.

FIG. 3. RESTORED HEAD OF *STYRACOSAURUS* MODELLED BY CHARLES W. GILMORE

The horned dinosaurs were the largest headed land animals of which we have knowledge, some of the skulls of old animals attaining a length of over eight feet. Although having such immense heads the brain is smaller in proportion to it than in any know vertebrate animal, being but little larger than a man's fist. The back part of the skull rises up into a kind of bony crest or frill as it is usually called, an arrangement doubtless effective as a protection to the vital parts of the neck.

After the many attempts of the horned dinosaurs to perfect their organization in order to bring it into harmony with their surroundings it seems rather hard that they should have been exterminated, but all things have their day, even dinosaurs.

THE USES OF TALC AND SOAPSTONE

WHILE talc is usually associated in the average mind with cosmetics there are a large number of applications which are little known and some of them not fully developed. The uses of talc and soapstone made the subject of a summarized list of present and possible future uses by R. B. Ladoo in *Chemical and Metallurgical Engineering*, October 11. Considerably more attention has been called to the technology and utilization of talc in Germany and Austria than in this country according to the author, notwithstanding the fact that the United States produces 65 per cent of the world's talc and Germany and Austria only 5.4 per cent. The Talc and Soapstone Producers' Association have decided to supply funds for research into the properties and uses of talc and as a result it is hoped that markets may be broadened. The list indicates the general specification under each head while we give here only the principal uses of powdered talc and soapstone, 57 of them:

- Paper manufacture
- Roofing paper manufacture
- Textile manufacture
- Rubber manufacture
- Paint manufacture
- Soap manufacture
- Foundry-facing manufacture
- Toilet preparations
- Wire-insulating compounds
- Lubricants—Liquid or grease
- Linoleum and oilcloth manufacture
- Pipe-covering compounds
- Pottery and porcelain
- Electrical insulation
- Rope and twine manufacture
- Leather manufacture
- Cork manufacture
- Oil manufacture
- Glass industry
- Portland cement and concrete
- Wall plaster
- Asbestos industry
- Manufacture of crayons, plaques and blocks
- Preservative coating on stonework
- Cleaning and polishing rice, peas, coffee, beans, maize, barley, peanuts and other similar foodstuffs
- Bleaching barley grain of inferior color
- Rubber stamp manufacture
- Composition floor manufacture
- Insulating material for switchboards, floors of generating stations, etc.
- Imitation stone
- Boot and shoe powder
- Glove powder
- Dermatology
- Absorbing colors of animal, plant and artificial origin
- Veterinary surgery
- Purification of waste waters
- Manufacture of water filters similar to Berkafeld
- Conserving fruits, vegetables and eggs
- Sugar refining
- Contact material for catalytic reactions
- Absorbent for nitroglycerine
- Packing material for metallic sodium and potassium
- Fireproofing wood
- Acid-proof and fireproof packing and cement
- Automobile polish
- Fertilizer manufacture
- Agriculture
- Shoe polish and cleaner
- Yarn and thread manufacture
- Chemical—Pharmaceutical industry
- Colored crayons
- Stove polishes
- Imitation amber
- Cleaning and glossing of hair and bristles
- Floor wax
- Terrzzo or Mosaic flooring
- Candy manufacture

The uses for massive talc and soapstone are presented as follows: Lava blanks for electrical insulation, gas burner tips, etc., crayons, pencils and special chalk such as tailors' chalk, refractories, glass making, and metallurgical industries, as a polishing agent for cooking utensils and in the form of blocks for carving, while slabs enter into the construction of hoods, tanks, sinks, and many domestic appliances.

AID FOR THE INDIAN POTTERY INDUSTRY

THAT the Bureau of Standards assists all the people in the country whenever it can is strikingly shown by the assistance which it rendered lately to the Hopi Indians in the manufacture of their pottery. This pottery is shipped to a considerable extent and has quite a wide sale, but, unfortunately, it is very fragile and has been subject to breakage. The Bureau has endeavored to determine the best manner for increasing the durability of the pottery and has still more recently undertaken to develop a black stain which will be superior to the kind previously used by the Indians. A stain has been produced which is very much better than the one at present largely used by the Indians and has the advantage that it produces a good color and can be made from very cheap materials. As a result of this work, a similar request for assistance has been received from the Zuni Indians of New Mexico.

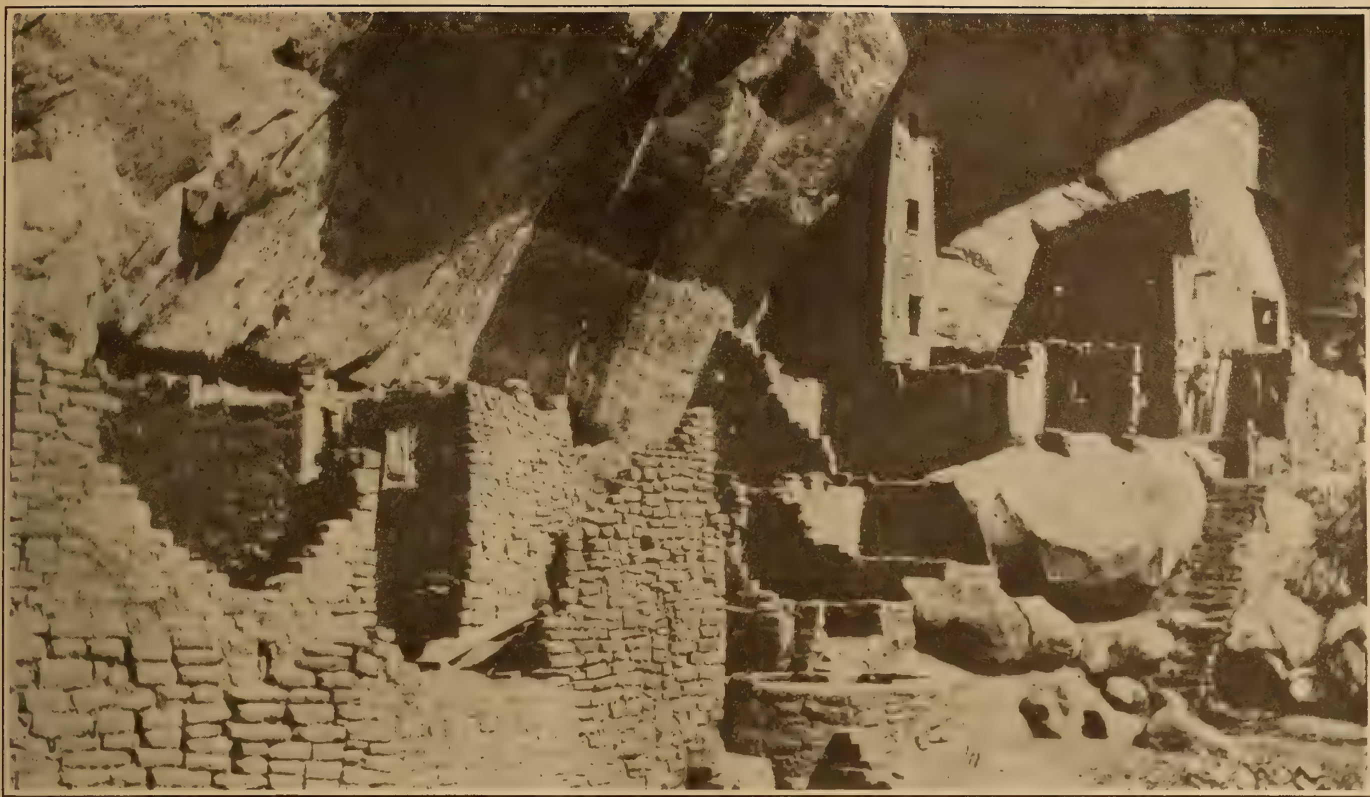


FIG. 1. SQUARE TOWER HOUSE EXCAVATED AND REPAIRED AS SEEN FROM THE SOUTHWEST
Photograph by Fred Jeep

Excavating Cliff Dwellings in Mesa Verde

Unique Structural Features of the Kivas of Square Tower House and Discovery of New Ruins

THE field-work of Dr. J. Walter Fewkes, Chief of the Bureau of American Ethnology, at the Mesa Verde National Park, in the summer of 1919, was devoted to the excavation and repair of the picturesque cliff dwelling, Square Tower House, known for many years as Peabody House, and two low prehistoric mounds situated among the cedars on top of the plateau. This work was a continuation of that of previous years and was carried on in coöperation with the National Park Service of the Department of the Interior. As Square Tower House has several unique structural features, the summer's work has added to the educational attractions of the Park. At least two new types of hitherto unknown small-house ruins were discovered, and it is believed that a new page has been added to the history of the Mesa Verde cliff people. Dr. Fewkes was assisted in his field-work by Mr. Ralph Linton, a temporary assistant, who contributed much to the success of the work.

The main object was to gather data that may aid one better to comprehend the Indian civilization that arose, flourished on the Mesa Verde, and disappeared from the plateau over four centuries ago.

Square Tower House is situated in a shallow cave at the head of a spur of Navaho Canyon opposite Echo Cliff, about 2 miles south of Spruce Tree Camp. It has long been considered by tourists one of the most atractive cliff dwellings of the park, but its inaccessibility has deterred all but the most venturesome from descending to it from the rim of the canyon. Part of the old Indian trail was indicated by shallow foot holes cut in the almost perpendicular cliffs, and previous to the past summer this was the only means of access. Without mutilating the vestiges of this primitive trail another was made in the cliff near it, around which was constructed a balustrade with ladders conveniently set to aid those who wish to visit the ruin.

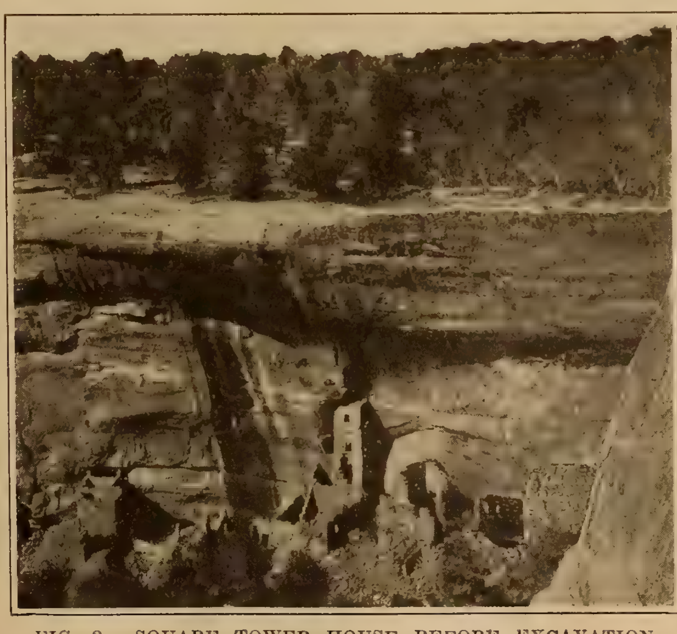


FIG. 2. SQUARE TOWER HOUSE BEFORE EXCAVATION AND REPAIR, FROM CANYON RIM

Square Tower House (Figs. 1 and 2) measures 140 feet in length and averages three stories high, with seven circular subterranean sanctuaries or kivas. The floor of the eastern end of the cave is composed of large boulders fallen from the roof; that of the western end is lower and comparatively level. The original entrance to the building, like that of the Cliff Palace,

*From *Smithsonian Miscellaneous Collections*, 1920, Vol. 72, No. 1, pp. 47-64.

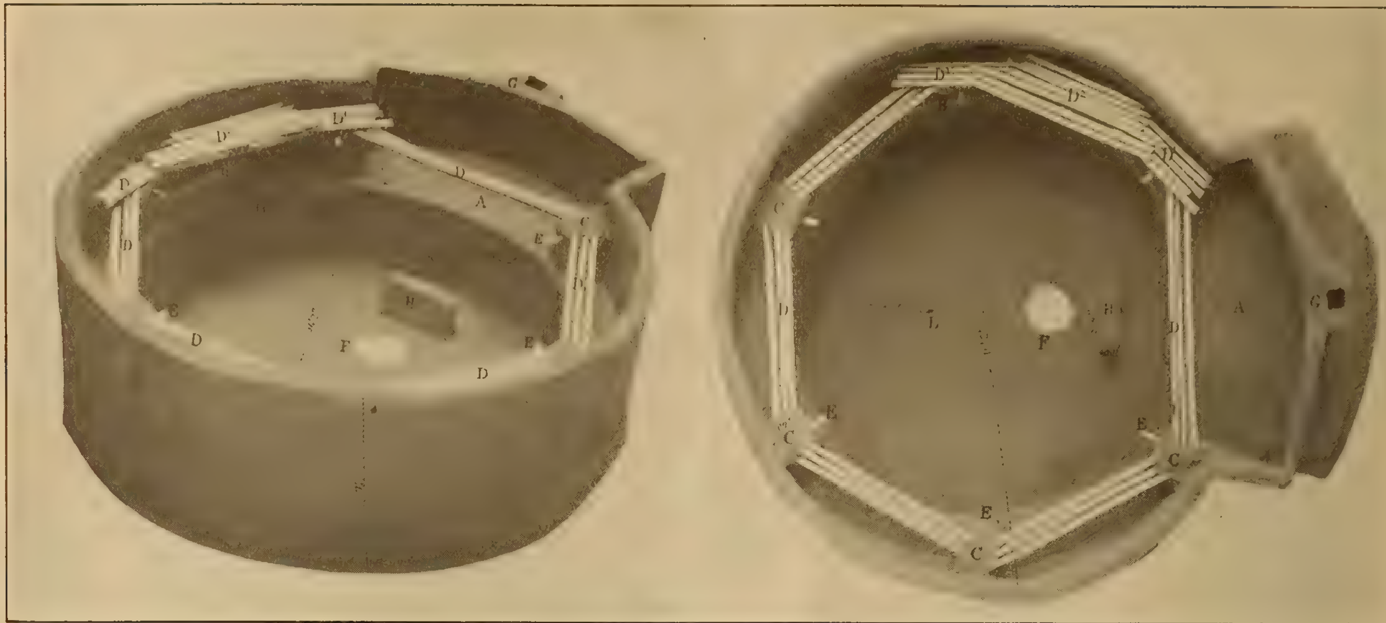


FIG. 3. MODEL OF A TYPICAL PREHISTORIC KIVA OF THE PURE PUEBLO TYPE

The photograph shows the model from above (*right*) and from the side (*left*), with first roof beams in place. A, large banquette; *B*, small banquettes; *C*, pilasters to support roof cribbing; *D*, beams of lower level of roof; D^1, beams of second level of roof; D^2, beams of third level of roof; D^3, logs to prevent sagging of roof; *E*, pegs for ceremonial paraphernalia; *F*, fire hole; *G*, external opening of ventilator; *H*, fire screen, or pure air deflector; *I*, niches for sacred meal; *K*, floor entrance to ventilator; *L*, ceremonial floor opening or *sipapu*. Photographs by De Lancey Gill.

Far View House, and Sun Temple, is a recess in the front wall. On the western end of the ruin there protrude radiating walls of basal rooms, one story high, suggesting a terrace. The rear wall of the cliff rises almost perpendicularly from the floor with no recess back of the buildings. The destructive effects of water dripping from the canyon rim are most marked midway in the length of the building where the walls (Fig. 1) now reduced to their foundations, were formerly at least two stories high.

The walls of the ruin were in bad condition when the work began: great gaps in the masonry of the tower having rendered it in danger of falling. The interiors of the rooms were choked with fallen stones and the dust of ages. Two months given to excavation and repair have put the ruin in fine condition, exhibiting a good example of the best type of Pueblo architecture. The special attractions of Square Tower House are the remains of the roofs of two kivas and the high tower rising midway in its length.

The original roof beams (Fig. 5) of these two kivas are almost wholly intact. Considering how few kiva roofs on the mesa have survived destruction in the lapse of time, especial care was exercised to preserve these and to indicate their mode of construction, and a model has been made, photographs of which, in successive stages of construction, are given in Figs. 3 and 4. A good understanding of the construction of a typical kiva is especially important, as it distinguishes cliff houses of the Mesa Verde from those found elsewhere in the Southwest as well as in foreign lands.

The kivas of Square Tower House are circular, subterranean in position, and entered by a hatchway. Each kiva has a fire hole *F*, and near it an opening in the floor called the sipapu, *L*, which is very sacred because it symbolizes the

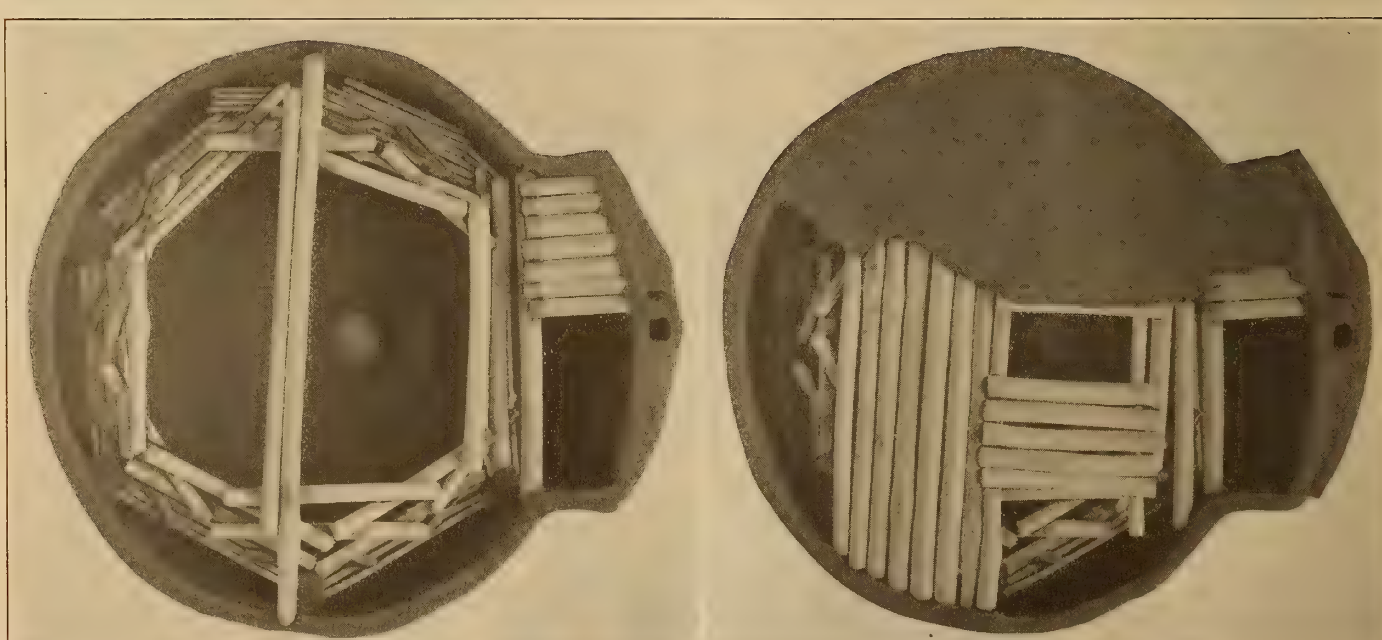


FIG. 4. MODEL OF TYPICAL KIVA OF THE PURE PUEBLO TYPE

Construction of roof beams is shown at the right, and the half-covered roof and hatchway at the left.
Photographs by De Lancey Gill.

entrance to the underworld. Over it in Hopi ceremonies is erected the altar, and through it the priests call to their kin in the underworld. A most instructive feature in the structure of the kiva is the means of ventilation. Between the fire hole and the wall there is an upright slab of stone, *H*, a wall of masonry, or simply upright sticks covered with clay. The function of this object is to deflect pure air which enters the room from a shaft opening outside, *G;* the ventilator is morphologically the survival of the doorway of the earth lodge or prototype of the kiva. A characteristic feature of the kiva is the roof, which rests on six mural pilasters, *C;* the intervals between which are called banquettes, *B*, that (*A*) over the ventilator being wider and broader than the others. The pilasters support logs, *D*, D^1, D^2, laid one above another in the form of cribbing. Short sticks, D^3, are placed at right angles to the cribbing to prevent sagging. Upon this cribbing are laid logs over which is spread cedar bark to support the clay covering the roof. The hatchway, which also served for the passage of smoke, is situated in the roof above the fire hole. In the construction of this roof, men of the Stone Age in America were not far from the discovery of the principle of the dome.

FIG. 5. VIEW FROM BELOW OF ONE SECTOR OF ORIGINAL ROOF LOGS OF KIVA A
Photograph by Gordon Parker.

The most striking feature of Square Tower House is the tower from which it takes its name. The cave in which it is situated having no recess at its back, there is consequently no refuse heap in the rear, such as was utilized at Spruce Tree House for mortuary purposes. The rear wall of the tower is formed by the perpendicular cliff (Fig. 6). As shown by windows, doorways, and remnants of flooring, this tower is four stories high. The inner plastering of the lowest story is painted white with a dado colored red; its roof is likewise well preserved.

A room near the western end (Fig. 9) of the ruin has doors and windows closed with secondary masonry, and in the rubbish, half filling the neighboring kivas, human bones were found, indicating that the western end of the ruin was deserted and used for mortuary purposes before the ruin itself was abandoned.

There is no archeological evidence that the tribes to the east, north and west of the cliff dwellers and stone house builders of the Pueblo area were stone masons. On the south of the area, in the valley of the Gila, Santa Cruz, and San Pedro, looking toward Mexico, the ancients built their houses of earth and logs, and while the prehistoric buildings on the southern tributaries of the San Juan resemble those on the Mesa Verde they are quite different from the pueblos now inhabited. A logical interpretation of the geographical distribution of ruins with kivas like those of Square Tower House would not be that the knowledge of stone masonry was introduced from Mexico, but that the craft was acquired after the original inhabitants entered the country, and that the pure pueblo type, or that with kivas like those of Square Tower House, was born, cradled, and reached its highest development in the area where it was found. But we may take another step, and point out that the prototype of these prehistoric kivas has a morphological likeness to "earth lodges."

The discovery of Earth Lodge A in this area by my assistant, Mr. Ralph Linton, was important, considering the light it may throw on the genesis of cliff dwellings. This ancient prototype (Fig. 7) of a kiva is a semicircular isolated room with a slightly depressed floor in which is a centrally placed firepit, the surrounding walls being either adobe plastered on the earth or molded into clumps shaped like rolls. In this rude sunken wall were set at an angle posts, now charred at the free ends, all that remains of the supports of roof and sides.

Earth Lodge A was not only excavated but a shed was built over it for permanent preservation. While it is interpreted as the prototype of a kiva, it was formerly the dwelling of a family or other social unit dating to an epoch much older than that of the cliff dwellers. On opposite sides of the fire hole at the periphery of the floor, but within the outer walls, are small square or rectangular cists made of stone slabs set on edge. The indications are that these were covered with sticks and clay, suggesting the so-called slab houses. The pottery found in these cists is very crude, undecorated, and not of cliff house type.

There are many sites resembling that of Earth Lodge A before excavation awaiting

FIG. 6. MIDDLE SECTION OF SQUARE TOWER HOUSE FROM THE CROW'S NEST
Photograph by Fred Jeep.

investigation on the top of Mesa Verde. Near it was a mound which when opened proved to be a unit-type house. The crude masonry and rough pottery found in it indicate an advance on the walls of an earth lodge, but the former is inferior to that of a kiva of the highest development, suggesting that it is an intermediate form between Earth Lodge A and Square Tower House. The spade revealed that after this room was first deserted débris had filled the depression a few feet deep on which a new fire hole and a grinding bin had been made of stone slabs on edge in the middle of the depression. Later on it was again abandoned and human bones had been thrown on the débris that formed over the grinding bin, indicating that the depression had become a dump place. Last of all, these were also covered by accumulated sand and soil, leaving only the top stones of a pilaster projecting above the surface.

FIG. 7. WALL OF EARTH LODGE A, SHOWING ADOBE PLASTERING ON EARTH; THE HORIZONTAL LOG IS A ROOF BEAM
Photograph by T. G. Lemmon.

FIG. 8. IDOL OF THE GERM-GOD SET BY AUTHOR IN CEMENT AT HEAD OF THE STAIRWAY, NEAR KIVA B
Photograph by Fred Jeep.

The pottery found in this crudely constructed kiva is more varied, but still an advance on that excavated in Earth Lodge A. It may be classified as black and white, and corrugated, but so inferior to that typical of cliff houses that it can be readily distinguished. From this ruin was taken a shard with a fine swastika, showing the antiquity of this design so rarely found in Mesa Verde.

The general facies of the collection of artifacts from Square Tower House is the same as in other cliff dwellings on the park, and although a few specimens are different from those already known, the majority corroborate, as far as age is concerned, the testimony of the buildings. A broken fragment of the rim of a vase of the sugar bowl pattern, a type peculiar to the upper San Juan area, was obtained from the Unit-Type House. Fragments of food bowls corrugated on the outside, black and white on the interior, belong to a type hitherto rare. No collector has thus far reported a prehistoric pipe from Mesa Verde, but a stumpy straight tube of unburnt clay, more like a "cloud blower" than a pipe, betrayed the fact that the cliff dwellers, like other Indians, smoked ceremonially.

On their altar at the great winter solstice ceremony at Walpi, one object of which is the increase of life by calling back the sun, the Hopi now employ an idol representing the god of germination. This idol is half oval in shape, the surface being painted with symbols of corn. A similar undecorated idol (Fig. 8), found at Square Tower House, one of the best ever collected, was cemented by the author in a conspicuous place at the head of the stairway.

FIG. 9. WESTERN END OF SQUARE TOWER HOUSE, EXCAVATED AND REPAIRED
Photograph by Fewkes.

An almost perfect reed mat, resembling those often deposited with the dead, was found in a room of Square Tower House. Good specimens of feathered cloth were wrapped around skeletons of infants. A fine pottery rest (Fig. 10), and a stick which shows excellent carving on one end (Fig. 11), occur in the collection; there are also many bone needles, basket fragments, and other objects similar to those elsewhere described.

A cubical stone with an incised design (Fig. 12) found in the same room as the idol of the germ god, is worthy of special mention as the maze or labyrinth depicted upon it is unlike any pictograph yet described from the Southwest.

Theoretically, Earth Lodge A is supposed to resemble forms of dwellings that have survived to our day among non-pueblo tribes. It has, however, an instructive feature they do not possess, viz., cists made of slabs of stone set on edge. Evi-

dences are accumulating of a culture antecedent to the pure pueblo type in which vertical masonry predominates, but we must wait more knowledge of the construction of the houses of this epoch before speculating on the early relations of the builders of vertical and horizontal masonry.

FIG. 10. POTTERY REST MADE OF AGAVE FIBER CORE WOUND WITH FEATHERED STRING

THE VOICE OF THE DEATH'S HEAD MOTH *

One of the minor problems of zoology which has been much debated is the means whereby the large moth known from its peculiar coloration as the Death's Head Moth, *Acheronita atropos L.*, produces its voice. In vol. 42 of the *Zoolog. Jahrbücher*, Prof. Prell undertakes to settle this question definitely once for all, citing with respect to it some 80 authorities from Réaumur (1736) on, by whom the most various opinions are expressed. Some seek the source of the sound in the abdomen, others in the thorax, and others still in the head. The majority hold the view that the noise is produced by the rubbing together of rough portions of the chitin, *i.e.*, by *stridulation*, while only a few ascribe the tone to the passage of air through the mouth or proboscis. As a general thing, in fact, the utterance of sounds by butterflies has been but little observed, and such cases as are known are almost certainly produced by organs of stridulation and are merely faint chirping noises.

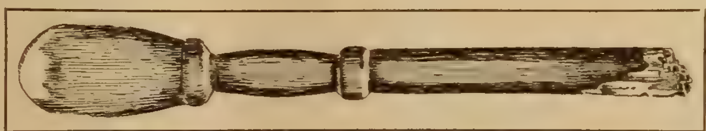


FIG. 11. STICK WITH CARVED EXTREMITY

But in the cry uttered by the Death's Head or hawk moth when disturbed, Prof. Prell distinguishes two notes—one being loud and grating and lasting longer than the other, while the other is shorter in duration and feebler as well as more shrill; this second note commonly follows the other at a brief interval, but may fail entirely when the cry is often repeated. While the cry is audible at a distance of several meters it varies both in strength and in height in different individuals.

It has now been established, by means of direct observation and by means of amputation, that the vocal apparatus is located in the head—even a head which has been decapitated, in fact, is still capable of uttering a cry.

The head of the insect contains a part of the anterior portion of the so-called pharynx, which is enabled by means of very powerful muscles to contract and to expand; this normally operates like a sort of suction and pressure pump for the purpose of taking in food and propelling it farther into the alimentary canal. But unless the mouth is immersed in a liquid it naturally can make use of this arrangement to draw in and expel air in the same manner with a considerable amount of force. The chief peculiarity of the Death's Head is that the *epipharynx*, an appendage of the upper lip found in all insects, is in this instance highly developed. It hangs from the roof of the mouth at the entrance to the pharynx like a sort of palate (*Velum palatinum*), and is capable of closing the mouth, but can be raised and lowered by means of muscles. When the inspired and expired air passes across this elastic plate of chitin—which is not unlike the vocal cords—it is made to vibrate and the rhythmic interruption of the current of air produces the sound described above. It is not unlike the sound produced in snoring (inhaling and exhaling the breath). The proboscis serves merely to intensify the sound.

Prof. Prell concludes therefore that this sound must be regarded as a *genuine vocal utterance*. This is without doubt correct: the sound producing apparatus of this butterfly may be compared to a reed-pipe, similar to the vocal apparatus of most land-dwelling vertebrates, whereas the musical instruments of most insects are constructed after the manner of stringed instruments, set in vibration by friction.

It must be borne in mind, however, that while the sound produced by this moth is actually made by the passage of the air in and out of the mouth, yet this is merely an exceptional use of an organ meant only for the taking in of food—for the mouth is no more an organ of respiration in this insect than in any other.

Most insects possess a breathing apparatus entirely independent of the mouth and consisting of the so-called "stigmata," which are present in great numbers. Hence this must be regarded as a wholly unique exception among articulated animals of the possession of a voice similar to that of land-dwelling vertebrates.

The sound made is a peculiar one, somewhat like the squeak of a mouse; it is superstitiously thought to foretell death or some other calamity.

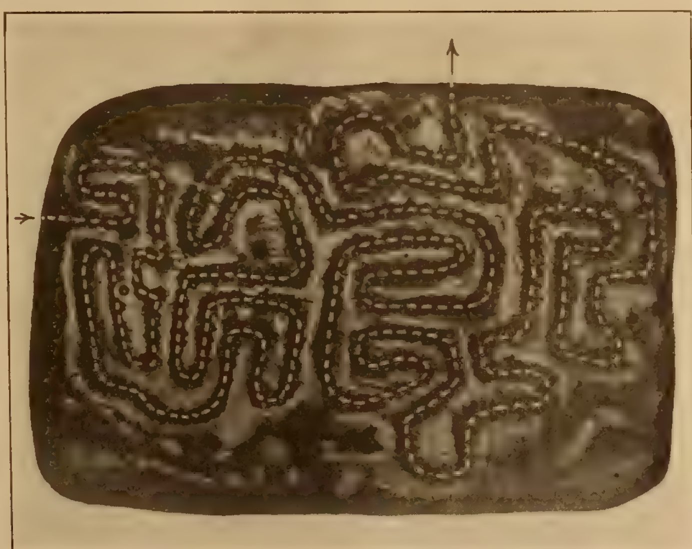


FIG. 12. INCISED MAZE ON ONE SIDE OF AN ARTIFICIALLY WORKED CUBICAL STONE FOUND WITH IDOL OF THE GERM-GOD

The dotted line does not exist on the specimen, but was placed there to enable the reader to trace the meander.

Photograph by T. G. Lemmon.

* Translated from *Kosmos* (Stuttgart).

Are "Harmless" Snakes Really Harmless?

New Studies Which Show the Poisonous Character of the Saliva of All Ophidians

During the last few years two well known French scientists, the late Dr. C. Phisalix, and his wife, Madame Marie Phisalix, have made extensive researches concerning the venom of snakes and other animals. They have made various interesting reports concerning this matter to the French Academy. Their conclusions are summed up comprehensively in the latter part of an article upon animal venoms in *Larousse Mensuel Illustré* (Paris) for June, 1920. The most remarkable of their conclusions is that *all* serpents are venomous in spite of the fact that it has hitherto been supposed that only those supplied with poison fangs secreted venom. They find that both the blood and the saliva of all ophidians are more or less venomous, so that when their dentition is complete the saliva at once penetrates the minute wounds made by the teeth; hence these species, which have hitherto been thought quite harmless are really as dangerous as those serpents which are provided with fangs. This venomous action has been thoroughly demonstrated by means of experiments made upon guinea pigs, birds, small rodents, and even upon lizards, with the secretion from the parotid glands of certain Colubers (snakes classed as being non-venomous and including the common grass snake). However, this order of snakes, the aglyphs do not all possess parotid glands: as a matter of fact, Madame Phisalix found only 72 thus provided out of 95 species examined by her.

But recent experiments have clearly proved the toxic action of the blood of Colubers, which is analogous to that of the serpents ordinarily known as venomous, *i.e.,* those possessed of poison fangs and known as proterogryphs (which include the cobras and asps) and solenoglyphs (which include vipers and rattlesnakes). A cubic centimeter of the serum of the smooth skinned Coluber (*Coronella Austriaca*) is capable of killing a frog in one hour and ten minutes, a sparrow in about the same time or five minutes more and the guinea pig in an hour and a half. The symptoms exhibited are stupor, paralysis of the respiratory apparatus and muscular paralysis. This serum does not lose its poisonous properties until it has been kept at a temperature of 60° C. for at least 15 minutes. Mme. Phisalix has also demonstrated the rabicidic properties of the serum of certain aglypha, including the ringed grass snake, the viperine Coluber and the Mauritanian turtle. All of these exhibit definite immunity against the virus of rabies. Furthermore, a contact of no less than 27 hours between the rabic virus and the heated serum of one of these reptiles is required before the mixture again becomes capable of producing rabies in animals inoculated with it—and even then the latter enjoy a temporary immunity.

These researches show, as P. A. Boulenger had already pointed out, that our present classification of serpents is inexact. Mme. Phisalix declares definitely: "The study of the venomous function is too general to be comprised within definite limits. The arrangement of the organs which produce venom, the independent evolution of the inoculating apparatus, the physiology of venoms, and the phenomena of natural immunity exhibited by venomous animals cannot be rationally employed as a basis of classification for ophidians."

Furthermore, it has been discovered that all the lower vertebrates are more or less venomous. Most fishes contain poison in small quantities, and perhaps this is why a too unvaried diet of fish sometimes has ill effects. The researches made by W. Kopaczewski, in particular, have shown the toxic nature of the serum of the murenoid eel (*Muraena* Helena); a dose of 30.5 $cm.^3$ of this is fatal to a guinea pig, 0.4 $cm.^3$ to a rabbit, and 1.5 $cm.^3$ to a dog weighing 5 kg.

Venom is found even more generally among batrachians. Mme. Phisalix has also studied these extensively, and she distinguishes two sorts of glands among them, whose secretions are of different nature, viz., *mucous* venom and *granular* venom.

Mucous Venom.—Mucous venom is that which is secreted by the mucous glands which are distributed over the entire body, being principally found upon the abdomen. It is colorless and venomous and acts upon the nerve centers. It exerts a paralyzing action and when injected into the veins of an animal produces stupor; the respiration suddenly ceases and always before the stopping of the heart. The water obtained merely by washing an ordinary edible green frog (*rana esculenta*) was sufficiently poisonous to kill two adult rabbits.

Granular Venom.—Granular venom is that furnished by the granular glands which are situated solely upon the dorsal surface and upon which depend the parotid glands situated behind the head. They are much larger than the mucous glands. The granular venom found on the back of the terrestrial salamander (*salamandra maculosa*) is a very active poison for cats and dogs. The principal symptoms produced by it are hallucination, terror, salivation, vomiting, and convulsions. The venom of the common toad (*bufo vulgaris*) has a paralytic effect causing a retardation first of the breathing and then of the heart action. Other symptoms vary with the species.

The Odor of Venom.—The poison secreted by batrachians varies greatly in odor. The venoms of the alzte, the pelobate, and the pelodyte smell like garlic; that of the calamite toad smells like powder. On the other hand both the common toad and the land-dwelling salamander produce a poison which possesses the deceptively agreeable fragrance of vanilla. The venom of the crested triton has the appetizing odor of horseradish, while that of the Japanese salamander resembles that of salol.

Venom in Blood and Eggs.—The venom of batrachians passes from their poison glands into their blood and is found even in their eggs. It disappears in the tadpoles and does not again appear until the glands are complete in the adult. There is enough venom in their blood to cause death to various animals when the serum is injected into their veins. But this venom is not present in the muscles, and this is why frog-legs are not only appetizing but nutritious instead of being poisonous.

Self Immunity.—All venomous animals are immune to their own venom. The reason for this is that their blood contains two antagonistic substances, mucous venom and granular venom, which neutralize each other. But the venom of batrachians is poisonous to man only when injected in his veins, which can only be done in the laboratory. In nature these creatures are not only inoffensive and interesting, but also very useful through their destruction of insects.

THE VENOM OF SAURIANS

Lizards.—The helodermian lizard (*heloderma suspectum*) is of peculiar interest in this connection. It is a most curious looking creature and has peculiar anatomical features; it differs greatly from other species of the same order. Its body is covered with conical tubercles like nail heads—whence its name. These are specially abundant upon the head. It has conical teeth on the inner edge of the jaw; these teeth each have two clearly marked longitudinal channels. This creature is sometimes over a yard long and is a horrific looking object. Mme. Phisalix made some curious observations concerning the venom of this animal. The poison affects the respiratory and cardiac action of mammals. On frogs it has the same effect as viper venom. The bite of this lizard is vigorously given and it hangs on to the victim a long time. By means of its channels each tooth makes a double injection in the bite, thus making forty punctures. A strong, active viper, 72 cm. long, died in 52 hours from a heloderma bite. On the other hand,

a heloderma bitten on the cheek by an active viper died in 24 hours, which shows the difference in the physiological action of the two venoms. The bite is sometimes fatal to man from the large quantity of venom injected. Mme. Phisalix herself was bitten on a finger, only one tooth entering the flesh. The bite was followed by severe pain of the entire arm, while the hand swelled and turned purple. This lasted for 3 hours, and it was several days before the hand was normal.

Scorpion Bites.—A scorpion bite in an adult is followed by lively pain at the locality, extending afterward to the whole limb. There is also a cold sweat, vomiting, and reduced temperature. The symptoms disappear in 24 hours if potassium permanganate is injected. In children the bite is more serious and may cause suffocation.

Venom as a Medicine.—The fact that a victim of epilepsy happened to be cured by being bitten by a rattlesnake has caused various investigators to test the medical action of venom. It is found that it greatly relieves epileptic attacks.

CHEMICAL AND BACTERIOLOGICAL TESTS OF EGGS

An exhaustive investigation of the chemical and bacteriological differences between fresh eggs and ordinary commercial eggs has been made by the Department of Agriculture, and has attracted attention not only in this country but abroad. The term fresh is properly applied to eggs only when they are less than twenty-four hours old and have been kept in a cool and well aired place ever since laid. Other eggs are divided into those which have been taken from a sitting hen and those which have not. The tests of these two classes of eggs yielded the following results:

1. The eggs gathered in July and August contain very few micro-organisms and in many cases no coli bacteria were present whatever.

2. The majority of the tests of eggs of the first class when the shells were clean had comparatively few bacteria and only 8.3 per cent of these possessed more than 1,000,000 germs in one gram by volume.

3. Eggs with dirty shells, or with cracks, or eggs with a yolk which mingled with the albumen contained over 1,000,000 germs per gram by volume, but likewise 16.6 per cent or 18.8 per cent or 20 per cent of them, respectively, were notably freer from coli bacteria than the first group.

4. Eggs having a speck of blood contained comparatively few bacteria; those having a large spot of blood were usually richer in bacteria than those with a small spot: the majority contained fewer than ten coli bacteria per gram of the volume of the egg.

5. The determination of ammonia nitrogen contents showed that the decomposition of the albumen was greater in the different kinds of commercial eggs than in the fresh eggs; but it was less than that of many eggs sold at retail. However, although a cracked or dirty shell indicated danger of infection and consequently decomposition, the tests showed that such eggs have as good keeping quality as those of the first class with clean shells, and that those collected in August and July are the best in this respect.

6. The eggs gathered in July and August and eggs of the first class with cracked or dirty shells can be employed without hesitation both in the household and the bakery.

7. Those eggs which were infected with bacteria included most of those in which the yolk had run into the white and most of those in which the yolk showed a tendency to cling to the shell as also all of those which were either partly or wholly musty or moldy and all of those in which the yolk stuck fast to the shell as likewise those in which the albumen was greenish in color.

8. All the eggs with yolks which exhibited a slight tendency to stick to the shell were less defective from the chemical point of view than the cooking egg of the first class, while the musty eggs, those with intermingled whites and yolks, those with greenish whites, and those with yolks which stuck tightly to the shell, usually exhibit a much greater degree of decomposition. The eggs with black spots contained five times as much ammonia nitrogen as the eggs in the previous groups. None of these eggs is fit for use either in the kitchen or in the bakery, with the exception of those in which the yolks stick but slightly to the shell.

AUTOMATIC PHOTOGRAPHY OF A BUTTERFLY'S WING

Some very curious biological experiments with respect to the self-recording power inherent in the delicate wing of a butterfly or a moth have been recently made by a German scientist named Gustaf Wolff.

When a butterfly's wing is laid for a considerable length of time upon a photographic plate, in a dark room, a clear image of the wing makes its appearance upon the plate when the latter is developed. In general the images are the positive character, the dark parts of the wing coming out most strongly, while white portions make no impression at all upon the plate Mr. Wolff states that it is the scales of the wing which exert the photographic influence, since when these are removed the wing fails to record itself upon the plate. Even the most delicate "hairs" which are generally dark in tint often make a very strong impression upon a sensitive plate. As everyone who has ever caught a butterly in his hand or clapped them off between his palms, knows the surface scales are very readily removed, since they form an absolutely homogeneous surface covering, they can actually be peeled off like a glove from the hand, if the wing be pressed upon a glass plate covered with moist gelatine and then removed. In making this experiment it is best to employ a dia-positive plate, which is first prepared then dried and again moistened, just before the wing is laid upon it. After the removal of the body of the wing it is found that the layer of scales adhering to the gelatine-covered plate, make exactly the same photographic impression that the entire wing did. The so-called "auto-type" thus obtained resembles a photograph in clearness and delicacy of detail. Brightly colored parts of the wing exert a very slight effect, if any, upon the plate.

Strange to say repetitions of these experiments show that sometimes positive images and sometimes negative ones are produced. In first experiments made with the swallow-tailed butterfly, for example, the black portions of the wing had no effect, while the bright yellow portions blackened the plate. But in later experiments these results were reversed, hence it is evident that there are both positive and negative swallow tails and that this distinction is individual in nature.

The effect exerted by the scales is able to penetrate thin paper and leaves of gelatine, but is unable to pass through celluloid and glass—even the thinnest watch crystals.

WEATHER AND THE OPENING OF COCOONS

The well-known Swiss scientist, M. A. Pictet, has made an extended series of experiments on the effect of the weather upon the opening of the cocoons of moths and butterflies. The data discovered and published by him are most interesting and obviously of great significance in agriculture, since hundreds of thousands of the farmer's worst enemies spend a portion of their lives in the cocoon phase. It was found that in most varieties of insects, the emergence of the pupa from the cocoon coincides with the fall of the barometer, and that a relative increase of the internal pressure within the cocoon is a necessary factor in the escape of the insect from its prison. When there is an augmentation of the atmospheric pressure during the entire time of this dormant stage of the pupa, or even during the latter half of this period alone, the duration of the dormant stage may be extended from 10 to 20 per cent. Furthermore, when the emergence of the insect is too long retarded, the pupa perishes while still in the cocoon.

A fall of a single millimeter of the mercury in the barometer tube was enough to cause the opening of the sufficiently mature cocoons, while, on the other hand, an increase in the atmospheric pressure was sufficient to postpone the coming forth of such insects for as much as two, three, or even four days until the barometer fell once more.

BREAK-UP OF A HERD OF SEALS AT THE CLOSE OF THE BREEDING SEASON IN THE EARLY FALL

Taking the Census of the Seals

How the U. S. Bureau of Fisheries Keeps Track of the Herds on Our Islands in Bering Sea

EACH year, in the late summer and early fall, a census is taken by the U. S. Bureau of Fisheries of the fur seals on the islands of St. George and St. Paul in the middle of the Bering Sea. This census is necessary as a check upon "blind killing" of the animals which would quickly result in their extinction. Last year's count showed 550,000.

When spring opens in the Far North the sleek and silken seals are to be seen moving toward the rocky, fog-hung shores where they were born. They come back from their annual migration for renewed courtship and battle, love and hate, life and death, after the manner of their kind. After the census is taken and the polar ice comes down they leave once more the Bering Sea. As to where they go for the winter after proceeding through the passes of the Aleutian Island chain, that is a source of mystery that has never been solved. They move southward in a great arc, fattening on candle fish, following a compelling instinct. After putting to sea none of them hauls to land again until the following summer.

This great seal herd has grown from a few thousands of not so long ago to more than half a million in a few years under a pledge with England, Japan and Russia, whereby the United States must share fur profits with these countries in return for prohibited open sea sealing.

The make up of the herd ranges from breeding cows, surplus and idle bulls to males from one to six years, yearling cows and pups. While in 1912 there were only 81,984 breeding cows there were in the 1919 census 142,015. The breeding bulls during the same number of years have increased from 1,358 to 5,344. The pups have increased in the same amount as the breeding cows, while the younger specimens now number many thousand more than they did eight years ago.

From time to time calls are made upon the United States Bureau of Fisheries by scientific institutions for specimens of the Alaska fur seal for exhibition or other purposes. There is no authority by law whereby animals may be killed to supply this demand. However, a few cows and bulls and a considerable number of pups are found dead on the rookeries each year and these afford a means of fulfilling such requirements. The existing law requires that all seal skins from the Pribilof Islands shall be sold and the proceeds turned into the treasury. In arriving at a price to be fixed for such specimens from dead animals, consideration has been taken of the fact that many of them are worthless commercially and for others it would be difficult to obtain an equitable appraisement. Therefore the sum of one dollar each was fixed as the value of the pups and five dollars each for the older animals. Institutions securing such specimens pay all charges for labor and transportation.

The Pribilof Islands where the seal breeds are of volcanic origin. The nearest land is Unalaska Island, 214 miles to the southward, and the next nearest is St. Matthew Island, 220 miles to the north. The distance of the islands from the mainland is a little more than 300 miles. The group comprises five islands, St. Paul and St. George, lying about forty miles apart, being the principal ones. On the shores of the two larger islands the fur seals have most of their breeding rookeries and hauling grounds. The rookeries are usually separated from each other by stretches of sand or abrupt cliffs, or in some cases by sections which have been abandoned. The breeding masses usually extend back from the water's edge but a short distance.

In 1868 and 1869 about 242,000 and 87,000 seals, respectively, were taken on the Pribilof Islands by various independent parties. In 1870 a law was enacted providing for the leasing of the sealing privilege for a term of tweny years, at an annual rental of not less than $50,000 and a tax of two dollars on each skin taken. Under the terms of this contract, a lease was entered into by the Government with the Alaska Commercial Company, a corporation including some of the American sealers who had operated on the islands in 1868 and 1869. This company agreed to pay an annual rental of $55,000 and a tax of two dollars sixty-two and one-half cents on each skin taken. Certain concessions were made to the natives and the right to make further rules and regulations governing the industry was vested in the Secretary of the Treasury. Under the lease the company took a quota of about 100,000 seals annually until 1889. The total number of skins taken on the islands during the twenty-year period was 1,977,377 and the revenue that these skins brought in

to the Government amounted to a total of $6,020,152.

New leases then jumped the annual rental to $60,000 per annum while the tax on each skin taken was raised to nine dollars and sixty-two cents. More liberal provisions were made for the care of the natives, and the number of seals to be killed annually was placed at the discretion of the Secretary of the Treasury. For the first year the number was 60,000. The leasing system was discontinued in 1910.

Recognizing that the brutal and wasteful killing at sea was greatly against the interests of the herd, the United States sought to establish jurisdiction in Bering Sea as a closed sea and seized a number of Canadian sealing vessels found operating there. This led to a controversy with Great Britain, which resulted in a treaty concluded February 29, 1892, consigning the whole matter to the deliberation of a tribunal of arbitration which met at Paris in the summer of 1893. Pending this treaty and the result of the deliberations of the tribunal, an agreement between the United States and Great Britain was entered into June, 1891, by which the latter country prohibited British subjects from sealing in the eastern part of Bering Sea, and the United States prohibited all killing whatever by its citizens excepting that of 7,500 seals annually for the food of the natives of the Pribilofs.

Among the results of the work of the Paris tribunal was a set of regulations closing to pelagic sealing a zone of 60 miles in radius about the Pribilof Islands, and prohibiting it entirely between May 1st and July 1st. These regulations went into effect in the summer of 1894, and of course affected only the citizens of the United States and Great Britain. They were subject to re-examination at intervals of five years. The experience of a single season showed that the result was ineffective, since the catch from pelagic sealing increased, and the seal herd continued to decline, and in 1896 this country accepted the proposal of Great Britain that the two countries institute independent scientific investigations of the entire matter at the close of the five-year trial period. These investigations were made in 1896 and 1897, and a voluminous report on the work of the American investigators was published in 1898. In the meantime, on December 29, 1897, Congress had enacted a law forbidding American citizens from engaging in pelagic sealing at any time or place.

OLD BULL SEAL AWAITING THE ARRIVAL OF THE COWS IN THE EARLY SPRING

In 1911 the United States, Great Britain, Russia and Japan entered into a treaty which abolished sealing on the high seas for a period of fifteen years. By its provisions the United States and Russia, as owners and guardians of the seal herds, agreed to pay Great Britain and Japan for the relinquishment of their interest in pelagic sealing a percentage of fifteen per cent to each of the product of the land sealing to be conducted by each of the two nations. In a like manner Japan agreed to pay to the United States, Great Britain and Russia, respectively, ten per cent from the land catch from the small but growing herd under her jurisdiction.

On August 4, 1912, the Congress of the United States passed a law prohibiting all killing of fur seals on the Pribilof Islands for a period of five years except the number needed as food for the natives, and providing for a breeding reserve of not less than 5,000 three-year-old males annually during the life of the treaty suspending pelagic sealing. Under the operation of this law only the skins of seals taken for food have been handled.

The work in connection with the Pribilof Islands expanded greatly in 1918 with the resumption of commercial killing of seals. A number of natives were secured from Unalaska to aid in the work, and temporary assistants were employed for sealing operations and general construction and repair work on the islands. Necessary transportation of supplies and products was furnished by the Bureau of Fisheries steamer department. Fur-seal skins and fox skins were taken and preserved as usual. A by-products plant was erected on St. Paul Island for the conversion of seal carcasses into oil and

COW SEALS JUST ARRIVED AT THE BREEDING GROUNDS

A GROUP OF FUR SEAL PUPS WAITING TO BE COUNTED

THE CENSUS TAKERS COUNTING THE MEMBERS OF A HERD ON ST. PAUL ISLAND

fertilizer. Cold-storage facilities were planned, and the general administration of the natives' affairs was carried on.

It is to make sure that no illegal killing is going on that every year the Government takes a census of the seals, and while it is impossible to make a full census without some proportion of estimate, at the same time the cessation of pelagic sealing has provided opportunity for actual counts of the breeding elements of the heard, the old males and females and the young of the year. With elements positively known and killing records complete for several years, the non-breeding seals can be estimated by making use of the number supposed to die from natural causes. At present the rate of mortality must be inferred, and herein lies the only element of uncertainty in the census.

The classes of seals actually counted are the breeding bulls in active service, the idle bulls on the breeding ground, and the young pups of the season. Actual counts are also made of the half bulls and bachelors, but give only partial results of value chiefly as a check upon the estimates. The classes estimated are the yearlings and the two-year-olds of both sexes, and the bachelors from three to five years of age. The number of breeding cows is directly inferred from the number of pups.

The method of counting is simple. The rookeries are mostly extended along the shore in linear formation frequently beneath low cliffs from which the observer can look over them with ease. In the present condition of the herd the number of bulls in tier formation between the shore and the back of the rookery does not often exceed five, and marked rocks and natural prominences are sufficient for all necessary subdivision of rookery space into areas for successive counting. The large relative size of the bull makes him conspicuous even at a considerable distance, and except when fully recumbent in a heavily massed area, he cannot possibly be overlooked.

In order to prevent mistakes and to make general preliminary observations, numerous counts of various classes of seals are made before the height of the season. In this way counts are made at least once for every rookery on St. Paul Island and some rookeries are counted from three to six times. In addition, weekly counts are made of all the rookeries on St. George Island in late June and early July. Therefore, when the height of the season arrives in September those engaged in the count are familiar with the peculiarities of each rookery and all are agreed as to the method to be employed.

Counting bachelors may be compared to counting a swarm of bees, part of which is in the hive and the remainder out gathering honey. The full number cannot be determined with accuracy although various devices are available as the basis of estimates. Those on land at a given time may be closely approximated by a process of combined counting and estimating. After some experience, results may be obtained in this way which, as minimum figures, are wholly reliable. It is often possible to find a herd of bachelors practically all of which are lying asleep, so an observer in an elevated position with a good field glass can count them with considerable accuracy. Conditions for counting in this manner are particularly favorable on St. George Island. A large herd of bachelors in which all or many individuals are in motion can only be estimated by counting those on a certain space and correlating the number obtained with the total space occupied. At times the bachelors on a given hauling ground may be driven back a short distance and divided into small pods which are successively counted as they form in an irregular line to return to the sea. Taking all data of this sort into consideration, the observer spending an entire season on the islands is in no doubt, as to the approximate number of bachelors usually found on each hauling ground.

Since 1897, when it was discovered that the number of pups greatly exceeds the number of cows on land at any one time, the importance of an enumeration of the pups has been apparent. Unlike the other classes of seals, all the pups for a time are on land at once, and the only obstacle in the way of exact knowledge of their number is that of actual enumeration. Until the abolition of pelagic sealing, however, a complete count of pups was not attempted, since it involved driving the cows into the sea and exposing them to the sealing fleet. Since 1912 with this danger past, complete counts of pups has been made. They not only give a measure of the new generation in the herd, but also furnish an accurate index of the number of breeding cows, since each cow gives birth annually to one pup.

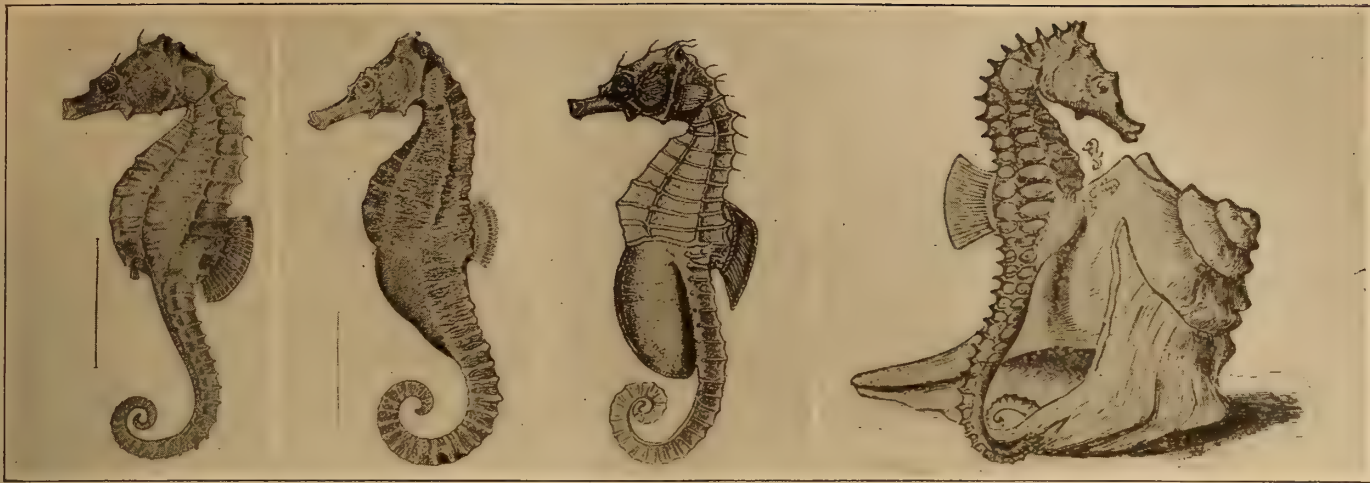
THE REMOVAL OF INK STAINS

By Dr. Gerhardt

The problem was to remove some ink stains from a cotton cover. The ink in question was an iron gallate ink. The spots withstood the action of warm oxalic acid, also a mixture of oxalic acid, citric acid and common table salt, as well as the simultaneous action of powdered tin and oxalic acid. After this treatment the spots became light blue in color, but could not be removed entirely.

The spots yielded, however, surprisingly easily to treatment with potassium permanganate ($KHnO_4$), mention of which fact could not be found anywhere in the literature. Several tests were made with this substance and all were so successful that it is recommended as a sure eradicator of ink stains on cotton. The method of procedure is somewhat as follows: The stains are first painted with a dilute permanganate solution (for example, about one ounce of the permanganate in a glass full of water). The solution was allowed to act a few minutes and then was washed away with water. The brown coloration was removed with sodium bisulphate (the photographer's "hypo") and citric acid, and finally the cloth was thoroughly rinsed out again with water.

When the cloth is dyed a test must be made on a small spot to see if this treatment does not remove the dye as well. It is well to paint the stain with an oil ring so that the treatment is limited within a very small range and so that the unstained cloth is not subjected to the action of the reagents.—*Zeits. angew. Chem.*, 1920 I. 32.



HOW THE SEAHORSE CARRIES ITS YOUNG IN A KANGAROO-LIKE POUCH

1. A female seahorse (*Hippocampus Hudsonius*). 2. Male (*Hippocampus alterimus*) with normal pouch. 3. Male (*Hippocampus Hudsonius*) with dilated pouch. 4. Male discharging young from pouch (after Lockwood)

Fishes with Prehensile Tails

The Odd Little Seahorse That Carries Its Young in a Pouch

THE convenience of a prehensile tail for animals which make their airy way swaying from bough to bough in the dense growth of tropic jungles is obvious enough, and the delight with which young and old regard this graceful exercise indulged in by monkeys, either free or captive, is possibly due in part to some deep atavistic consciousness of a time when man, or his immediate progenitors, enjoyed a similar advantage. But what need have the denizens of the deep of such an implement? None at all obviously so far as the fishes who dwell in really deep waters are concerned, but there are certain curious little fishes, the seahorses and their cousins, the pipe-fishes, which live in shallow waters near shore and commonly haunt the miniature jungles of eel grass and seaweed, who find such a power of grasping the surrounding vegetation extremely useful, and who have accordingly developed this prehensile action in a remarkable degree.

This power is all the more useful to them because their powers of locomotion are very poor. The swift moving crustaceans, worms, etc., on which they feed could easily escape them did they depend merely on the chase, but this power of anchoring themselves to a bit of eel grass enables them to lie in ambush and snatch their prey as it darts past. They are further aided by the strong power of suction they possess through their long snouts which resemble pipes or muzzles as the case may be.

The most curious feature exhibited by these fishes, however, is the pouch in which the young are carried, much as the young of a kangaroo are carried in the mother's pouch. Strange to say, however, in the seahorses and in those of the pipe fishes which possess this feature, it is the male parent who thus carries his offspring about with him. As our pictures show the pouch before the eggs are laid in it by the mother is flat and inconspicuous, whereas later it is distended

GENERAL FEATURES AND HABITS

While the seahorses or Hippocampids vary in form to some extent there are typical features common to all of them. Thus all have very rigid compressed bodies, hemmed in by plates, which are so connected that the animal is incapable of bending sidewise to any great extent. All of them have long curving four-sided tails—this tail is more or less prehensile, in typical forms very highly so. This, indeed, is one of the most characteristic features of the fish, since, as we have said, it alone and some of its cousins, the pipe fishes, are provided with these so-called grasping tails. The tail is employed to anchor the fish to the seaweeds or eel grass which is its favorite resort and where it finds not only shelter but its favorite food in the form of the small spiral worms and the tiny crustaceans upon which it lives. While the seahorse generally keeps an erect position, both when swimming and while at rest, it sometimes extends the body at an angle or even in a downward direction from the spot to which it is clinging; occasionally the tail is even wrapped in a double coil around the plant.

Because of the almost inflexible coat of mail in which its body is enclosed, the seahorse cannot move as ordinary fishes do, by bending the body from side to side, but this difficulty of movement is largely compensated for, not only by the strength and flexibility of the tail but by the fact that the air bladder is unusually large and is always distended by an amount of air which so exactly corresponds with the amount required by the specific gravity of the body as to form an extremely sensitive hydrostatic apparatus. A proof of this is furnished by the statement of Theodore Gill that if a single bubble of air, no larger than the head of a very small pin, be lost through a puncture of the air bladder, the fish immediately loses its balance and falls to the bottom, upon which it is forced to crawl about until the air bladder is healed and once more air tight; this air bladder is really filled by a sort of "gas" which is secreted by its inner membrane.

VARIOUS SPECIES OF THE SEAHORSE

There are between 30 and 40 species of *Hippocampus*, the distinctions between them being based chiefly on the number and the length of the rays composing the dorsal fin, the number of rings encircling the body, the comparative lengths of the body and tail behind the anus, the depth of the body or distance across from the dorsal ridge to the ventral, and the relative length of the head and snout in front of the eyes. These are supplemented by the comparative development of the tubercles or spines, of the coronet at the crown of the head or nape, of the filaments with which the body may be covered, and the color.

The common eastern American seahorse (*Hippocampus hudsonius*) has a long dorsal with about 19 rays, about 45 (10 + 32-35) rings, the tail longer than head and trunk combined, the snout short but appreciably longer than rest of head (1.3—1.4:1), and the depth of the body approximately equals the length of the head. The coronet is little developed, the tubercles and spines weak, and the filaments rather few,

short, and mostly simple. The color is dusky and spotless (but blotched) and the dorsal has a submarginal dark band. This species was up to some two years ago very common in the vicinity of New York harbor, but the bitter winter then experienced killed it off.

The sea-wrack seahorse (*Hippocampus zosteræ*) of Florida contrasts with the common species of the north in most of its characters. It has a short dorsal (covering only 3 rings) with about 12 rays, about 41 (11 + 30) rings, the tail rather shorter than the rest of the body, the snout extremely short and not more than half the rest of the head, and the depth of the body great and almost equal to length from snout to margin of pectoral fins. The coronet is high, the spines are well developed, and the filaments moderate and often branched. The color is olive green, more or less mottled, and the dorsal has no distinct submarginal head. It is, according to Jordan and Evermann, "the smallest known species of seahorse, abundant in shallow water in the lagoons, always found clinging by its tail to the sea-wrack (*Zostera marina*)."

While the more common species of *Hippocampus* are certainly singular enough in aspect, certain ones found in tropical seas are still more exaggerated in form. The oldest looking of all are the *Phyllopteryx foliatus* and the *Phycodurus eques;* the former exhibits a really marvelous simulation of a bit of the seaweed among which it makes its habitat. This strange foliated structure is due to the enormous development, especially around the tail, of certain cutaneous appendages which are in most species merely tags of skin.

YOUNG SEAHORSE VIEWED AS A TRANSPARENT OBJECT
At right, very young seahorse with yelk sac

Seahorses have a very curious method of feeding. Because of their slow motion they would have great difficulty in catching the little crustaceans, such as sand fleas, opossum shrimps, upon which they mainly feed (though they are willing to eat mosquito larvæ and other water insects) except for their power of exerting a strong suction through their long snouts, but even so the prey must be at rest, either on a plant or at the bottom.

HOW THE YOUNG ARE CARRIED

Strangest of all the habits of the seahorse is, as we have said in the introduction to this article, its custom of incubating the young in a pouch, after the manner of kangaroos and opossums, but this pouch belongs not to the mother fish but to the father. The mating season, in these waters, at any rate, is in early summer, and at this time the female deposits her eggs in the pouch of the male which, as our picture shows, is situated just below the "cuirass" of the body at the beginning of the tail. This pouch is especially adapted, not only for holding the eggs until they are hatched but, also, for nourishing the newly hatched babies. The pouch becomes thickened and vascular at this time of the year and is lined with a mucous membrane which secretes "an aeriform fluid." According to Lockwood, when ready to receive the spawn, the wall of the pouch is not less than three lines thick and is well stored inside with fat. When the young fry is expelled after being sufficiently developed, on the other hand, the pouch has become merely a thin loose membrane hardly half a line in thickness.

The young not only live in the father's pouch for some time after their birth, but are accustomed when old enough to make private expeditions from it in search of food, returning like fledglings to a nest; but when the patient parent begins to find them a burden he does not hesitate to evict them from their happy home, either by curling his tail underneath the pouch and exerting a strong upward pressure which forces the young out, or else by literally scraping them out against some convenient object, such as the winkle shell shown in our illustration.

This picture was drawn by Lockwood and the operation it represents, which, by the way, is by no means actual "labor" in the specific sense of that word, but is merely mechanical, is thus described by him: "With its abdomen turned toward the shell, its tail attached to the under part of it, the body erected to its full height, the animal, by a contractile exertion of the proper muscles, would draw itself downward and against the shell, thus rubbing the pouch upward, and in this simple yet effective way, expelled the fry at the opening on top of the sack." This is not a continuous operation, but each effort was "followed by a few minutes of rest," and the extrusion of the young "lasted for nearly six hours, from three to six individuals being set free at a time." The young are then fully developed.

PROTECTIVE COLORING

While the dense growth of eel grass or seaweed, which is the common habitat of these fish, affords a refuge for enemies as well as an excellent ambush not to say a happy hunting ground, the fishes also present a very interesting protective coloring which varies from place to place according to the varying colors found in the environment. Thus among the brilliant rocks and vegetation of the southern Mediterranean they disport themselves in all the colors of the rainbow. These very fish however, when removed to the more sober surroundings of northern waters quickly assume the soft brownish and greenish hues of the surrounding vegetation.

When the fish lets go its hold, described above, upon the supporting object, it moves slowly away still in a vertical position, with its tail curved inward and its dorsal fin vibrating rapidly, so as to remind one of the propeller of a boat. The pectoral fins vibrate in unison and in both cases the rapidity of the undulatory movement is very remarkable.

Mechanism of Sound Production.—"The sharp, little, snapping noise" made by these fishes is very characteristic. It is produced by the abrupt opening and closing of the lower jaw and the muscular motion involved in this was found by Dufossé to consist of a series of movements so extremely slight and so rapid as to be invisible, though they can be perceived by the sense of touch, as a sort of vibration or quivering motion. Both sexes produce these sounds and they are most intense in the breeding season, and probably assist in the matter of courtship.

It was Lockwood who first observed the phenomenon. While drawing certain specimens placed in separate dishes he heard the staccato noises referred to and found them to be coming from one of the glass dishes. Almost immediately the sounds or signals were answered from the other vessel, and doubtless the little creatures were comforted and reassured amidst their strange and alarming surroundings by this conversation.

Fish that Bear Their Young Alive

Curious Habits of Kilifishes, Cave-Fishes, Sharks, Rays, Etc.

THE habit of laying eggs is so nearly universal among fishes that probably most people will be considerably surprised to learn that certain species of various families of them actually bear their young alive. Among these is the large family of kilifishes, or *Cyprinodontidae*, sometimes known as toothed carps.

About one hundred and forty species are now known, from the streams and brackish lagoons of the eastern United States, tropical and South America, Africa and Asia. Few are found in Europe, and few in the north Pacific region, and none much north of the latitude of Boston. The majority frequent brackish lagoons, lowland swamps, and mouths of rivers, but the strictly fresh water species often abound in the clear fountain-heads of streams. Some African species live in hot springs.

The species are all of small size, some of them (*Heterandria*) being the smallest known vertebrates. The largest species (*Anableps, Fundulus*) seldom reach the length of a foot. In most species the sexes are dissimilar, and in several genera the anal fin of the male fish is modified into an intromittent organ, whereby the ova are fertilized before extrusion. In such species the young are developed in a sort of uterus and are born at a comparatively advanced stage of development. When born they closely resemble the adult fish. All of them are very tenacious of life.

That the bearing of the young alive by certain fish is not significant of a higher state of evolution, as the layman might naturally suppose, is proved by the fact that it occurs in many species of the sharks and their cousins the rays, though these are among the earliest, i.e., the most ancient fishes that we know. This habit of procreation has been developed among certain species of widely various families according to local conditions in order to give the young fry a better chance for survival than they might otherwise have—it is literally a case of "fewer babies but better ones." In some sharks there is a structure analogous to the placenta found in mammals, but it is not of the same character or origin. There is actual union in the case of viviparous fishes and there is accordingly a modification in most cases of some organ, as was remarked above, so as to fit it for effecting the transfer of the fecundatial cells. This is the purpose of the sword-shaped anal fin in many top-minnows, while in the Elasmobranchs large cartilaginous organs known as claspers are developed from the ventral fins.

GIRARDINUS VECTICULATUS (*GUPPYI*)—A VIVIPAROUS FISH COMMONLY CALLED THE TROPICAL FISH

Among the rockfishes and the rosefishes the young fry are exceedingly small when first born, while in the surf-fishes they are large and few in number, as is also the case in the sharks.

An interesting example of a viviparous fish in which the young are minute in size and produced in large numbers is the blennie. A writer in the Royal Natural History thus describes them: "The fry, which at birth are perfectly transparent, and form beautiful objects for the microscope, are so fully developed as to be able at once to swim freely on leaving the body of the female parent. Before their birth the female bcomes so distended, that at the slightest pressure the young are extruded; these frequently being from two to three hundred in number, and always making their appearance in the world head first. The general color of the fish is pale-brown, with the dorsal fin and upper parts mottled and barred with darker brown.

Most of the viviparous species feed upon mud; the rest upon insects and other small organism. They are generally surface fishes and swim slowly about with their eyes half in and half out of the water. The most curious of all these is the genus *Anableps* which lives in the streams of the American tropics. This is sometimes called the four-eyed fish, for the reason that its large prominent eyes which actually resemble marbles on top of the head are divided horizontally into two parts, the lower half being fitted for water vision and the upper half for air vision.

Here, as so often, we find in nature a preliminary use of one of man's boasted inventions, the bifocal spectacles. These fishes are the largest of the *Cyprinodontidae*, sometimes being a foot or more in length.

Another member of the family, however, a pretty little fish, living in southern lowlands, is the smallest of all known fishes, being rarely more than half an inch long. This tiny creature bears the formidable name of *Heterandrie formosa*. Other genera include the *Jordanella* which look somewhat like young sun-fish and which are found in the lakes and everglades of Florida, the *Cyprinodon*, a small, chubby, carnivorous fish found on the shores of America and southern Europe, the *Fundulus* which is widely distributed in both fresh water and salt, and the *Ganbusia*, one species of which abounds in the swamps and brooks of southern lowlands. In this species the males are not only smaller than the females but far less numerous.

Cave Fishes.—Closely allied to the family just described are the remarkable cave fishes or *Amblyopsidae*. In these the young fish are only one-fourth of an inch long. Only five species are known, the largest of which is only five inches long. They live in the streams which run through the caves which abound in Kentucky, Tennessee, Alabama, Illinois and Indiana, and a single species is found in the ditches of the rice fields of South Carolina.

Two of the species inhabit only the depths of the subterranean rivers. In these the eyes consist of a mere useless rudiment hidden beneath the skin. As a compensation for this blindness, however, the head and body are covered with numerous rows of highly sensitive papillae which form a very delicate organ of touch. The body is translucent and colorless.

In the genus *Chologaster*, the celebrated fish of the Dismal Swamp, on the other hand, the eyes are well developed and the body decked with color as is usual in fishes. Directly descended from the *Cholgaster* are the blind fish found in the limestone caves which abound from Southern Indiana to Northern Alabama. Only the Mammoth Cave blind fish *Amblyopsis speloeus* is common in collections, the others being rather rare. In these fishes the vent is peculiarly situated instead of behind the ventral fin as usual.

Professor Cope makes the following interesting statement about them: "If these *Amblyopsis* be not alarmed they come to the surface to feed and swim about like white aquatic ghosts. They are then easily taken by the hand or net if perfect silence be preserved, for they are unconscious of the presence of an enemy except through the sense of hearing. The sense is, however, evidently very acute, for at any noise they turn suddenly downward and hide beneath stones, etc., at the bottom. They must take much of their food near the surface as the life of the depth is apparently very sparse. This habit is rendered easy by the structure of the fish, for the mouth is directed upward and the head is very flat above, thus allowing the mouth to be at the surface."

DEGENERATION OF THE EYE IN CAVE FISHES

The gradual degeneration in the eye of these cave fishes is a very instructive phenomenon. It has been studied in close detail by Dr. Carl H. Eigenmann. He divides the history of the eye of *Amblyopsis spelæus* into four periods: The first extends from the appearance of the eye until the embryo is 4.5 mm. long, and there is a normal palingenic development except that the cell division is retarded and there is very little growth. The second period lasts until the fish is 10 mm. long, and during this time the eye continues to develop till it reaches the highest stage attained by the *Amblyopsis* eye. The third period continues until the fish is from 80 to 100 mm. long. During this time various changes, some progressive, some of them distinctly degenerative, take place. The fourth and final period continues until death and is characterized by degenerative processes alone.

While the eye of the *Amblyopsis* appears at the same stage of growth as in normal fishes, it grows but little after making its appearance. The lens appears at the normal time and in the normal way, but its cells never divide and always remain embryonic in character. It is the lens which first exhibits signs of degeneration and it disappears entirely before the fish is 10 mm. long. The optic nerve exhibits itself just before the fish attains a length of 5 mm. It does not increase in size as the fish grows and it disappears in old age. The scleral cartilages appear when the fish is 10 mm. long and grow very slowly, possibly till old age.

Dr. Eigenmann says: "It is evident that the causes controlling the development of the eye are hereditarily established in the egg by an accumulation of such degenerative changes as are still perceptible in the eye of the adult."

Two theories exist as to the cause of the loss of eyesight, according to Dr. Jordan, namely, the Lamarckian theory of the inheritance in the species of the results of disuse in the individual and the Weissmann doctrine that the loss of sight results from cessation or reversal of selection. Dr. Eigenmann inclines to the former belief but Dr. Jordan is uninfluenced by his views.

We may close this account by a quotation from notes made by Miss Ruth Hoppin, of a fish taken from a well in Jaspar County, Missouri. This was a blind fish of the species *Troglichthys rosae.*

"He seems perfectly healthy and as lively as when first taken from the well. I gave him considerable water, changed once a day, and kept him in an uninhabited place subject to as few changes of temperature as possible. If not capable of long fasts he must live on small organisms my eye cannot discern. He is hardly ever still, but moves about the sides of the vessel constantly, down and up, as if needing the air. He never swims through the body of the water away from the sides unless disturbed. Passing the finger over the sides of the vessel under water, I find it slippery. I am careful not to disturb this slimy coating when the water is changed.

"Numerous tests convince me that it is through the sense of touch and not hearing that he is disturbed. I may scream or strike metal bodies together over him as near as possible, yet he seems to take no notice. If I strike the vessel so that the water is set in motion he darts away from that side through the mass of water instead of around in his usual way. If I stir the water or touch the fish, no matter how lightly, his actions are the same."

USING DEVIL FISH FOR GRAPPLING IRONS*

By Dr. C. Ishikawa

One of the ways in which Japanese fishers catch the devil fish, *polypus vulgaris Lam* (*octopus octopodia*, L.), is as follows:

At the end of a stout bamboo rod two strong hooks are fastened while above them is the bait upon a small hook. At the other end of the rod and upon the oposite side a sinker is attached. The whole apparatus is hung upon a very long line and lowered to the bottom of the sea so as to lie there in a slanting position; it is then jiggled up and down gently which causes the bait to move with an appearance of life. As soon as the fisherman sees a polyp catch hold of the bait, he seeks to jerk the line in such a manner as to catch the hook into the flesh of the animal and draw it to the surface.

This apparatus is used in different parts of Japan, being the same in general principle but varying somewhat in size and manner of construction. The apparatus used in the neighbodhood of Hasihama in Ijo, upon the Island of Sikoku, consists of a piece of bamboo about 13 cm. in length, ½ cm. in width, and 1 cm. in thickness. The upper half of the piece of bamboo widens out into a spoon-like shape measuring 26 mm. at its greatest width. The smooth, hard outer side of the piece of bamboo is directed to the front, and the inner side to the rear. At the point of the narrow part upon the outer side (which lies upward when the apparatus is resting on the bottom of the sea) two strong hooks are fastened with a rope; the points of the hooks are directed toward the broad portion of the piece of bamboo. One end of the rope is left free and used for attaching the bait. In the middle of the piece of bamboo and upon the same side a small hook is attached with its point extending in the opposite direction; this hook is used for holding the bait. A small triangular iron sinker, about 4½ cm. long and 3 cm. wide at the bottom, is loosely attached to the broad part of the bamboo by means of a flexible piece of wire. The piece of bamboo ends in a knob at this point to facilitate the attachment to the rope.

Most of the octopus catchers in this neighborhood live upon the little Island Kurusima . . . Just here there is a very strong current in the sea which has long been regarded by the fishermen as very dangerous. About fifty fishers dwell upon this charming little island and more than half of them are engaged in polyp fishing. These animals are found here in such abundance that a fisherman often is able to catch from fifty to seventy-five kilograms in a single day. The depth of this passage averages about 50 meters; the bottom is mostly covered with small blocks of stone under which the polyps take refuge.

As we have said, this passage has long been perilous to ships on account of the strength of the current and many romantic tales are told of the accidents hereabouts. In former times the vicinity was notorious for the sea pirates who made their headquarters here, since it was an excellent place to lie in wait for passing ships. Among the oft told tales still current is the following:

More than three hundred years ago the famous conqueror of Korea, Hideyosi Toyotomi, had reduced the entire realm of Japan to a state of peace. One day he ordered his vassal, Yurakusai Ota, to make a collection of rare pieces of porcelain from various quarters of the kingdom for use in the ceremonial tea drinkings, which at that time were very popular among the upper classes. This order was passed on to another man, Uyeda, who promptly set forth for Kyusyu to fetch certain rare specimens. Upon his return journey a violent storm burst forth as he neared Hasihama and after a perilous struggle the ship laid to in a small bay. Uyeda went

*Translated from *Kosmos* (Berlin) for the *Scientific American Monthly.*

ashore and sought refuge in a farmhouse to wait until the storm had passed. While he rested there the captain of the ship happened to get news of the death of the mighty ruler who had given the commission for the collection of the china (1598). The captain, who was none too honest, made use of the opportunity to steal the valuable specimens of the collection and take French leave, first taking the precaution to sink the ship. When the unfortunate Uyeda found his ship and his china at the bottom of the sea, he ceremoniously committed harikari. The sympathetic villagers buried him and erected a small temple above his bones to keep him in remembrance. As years passed by the adventure of the porcelain ship gradually became merely a dim legend. But one day the fisherman Kujuro made an astonishing catch. From a depth of thirty fathoms he brought up a polyp which clutched tightly a rarely beautiful piece of porcelain. This happened in June, 1828.

The fisherman remembered the ancient story about the shipwrecked cargo of porcelain and found upon inquiry that the dish he had thus luckily retrieved came from the celebrated city of Karatsu in Kyusyu. He kept his lucky find a secret but at once began recovering choice pieces of porcelain by

A JAPANESE METHOD OF CATCHING DEVIL FISH

means of living polyps. For this purpose he knotted together three strong ropes, each about 36 cm. in length at the same point. He then fastened a living polyp of moderate size to each of two of these ropes, tying the rope firmly about one arm of the animal, the sinker being attached to the third rope; finally a long rope was tied about the place where the other three were knotted together. This apparatus was let down until the living polyp touched ground. As soon as this happened the creature naturally began to crawl away and to assist itself in this effort, it laid hold of rocks and other objects on the bottom of the sea. It was possible to tell when it had attached itself to such an object by the pull upon the rope. Thereupon the rope was quickly drawn in. the animal meanwhile clinging desperately to whatever it had laid hold of, whether this was a stone or a choice piece of porcelain.

In this manner Kujuro succeeded in obtaining a great many valuable pieces of old china which brought a large price in the market. This thrifty enterprise was continued by his sons and gradually this secret hoard of beautiful porcelain received the name of "Karatsu-Iso," *i.e.*, Karatsu Beach porcelain. . . .

Naturally this porcelain is not in very good condition. The salt water has somewhat corroded the surface so as to roughen it. However, this only enhances its value in the eyes of the devotees of the "tea ceremony." Many charming pieces, however, are in perfect condition, even as regards the drawings and paintings with which they are adorned. Some of them have gained in interest if not in beauty by the sea creatures which have clung to them, such as rock-boring mussels and tube-building worms. One particularly fine piece is a beautifully lacquered sword sheath. The blade itself has entirely disappeared under the action of the salt water, but the lacquer is in a marvelous state of preservation, not showing the slightest abrasion after the lapse of 300 years. Since this curious art of porcelain fishing has now been practised for more than twenty-five years, the pieces are becoming rarer and rarer, so that at the present they are seldom brought up.

THE SELECTION OF FOOD PLANTS BY INSECTS

In the *American Naturalist* for July-August, 1920, Dr. Charles T. Brues of the Bussey Institution of Harvard University gives an account of his study of the selection of food plants by insects, with special reference to Lepidoptera larvæ. Dr. Brues finds that the Lepidopterous insects show a very fixed instinct to select definite plants for larval food and that many are extremely precise in this respect, although some are less so, and others are quite catholic in their tastes. Furthermore there is much to show the existence of a so-called "botanical instinct" in species, genera and even families, whereby evidently related plants and these only serve as food. A few species have departed from the general habit so far that they have become carnivorous.

To avoid numerous difficulties it seems clear to Dr. Brues that the selection of food-plants by the Lepidopterous insects studied by him must be considered as dependent upon one or several of a number of factors. Among these he includes the following:

1. The odor of the plant and also its taste, which is no doubt closely connected with odor. Associations reasonably placed in this category would be the oligophagous species occurring, for example, on various Cruciferae, various Umbelliferæ, and various Compositæ. An additional argument for the importance of this factor is seen in the less common utilization by the same insect of several plants in a family like the Solanaceæ where a more or less similar odor does not become a family characteristic.

2. Some attribute of the plant, perhaps an odor, but far less pronounced to our own senses than those mentioned above. Species restricted to plants like Leguminosæ or Violaceæ may be considered in this category. Undoubtedly there is some attribute of such plants which insects can recognize in a general way and not as a specific characteristic of some single plant species or genus. The "botanical instinct" of some caterpillars that has frequently been commented upon would appear to be an exaggerated power of recognition of this sort.

3. A similarity in the immediate environment or general form of the food-plant. The effect of something of this sort is seen particularly in oligophagous and also polyphagous caterpillars feeding mainly on trees or shrubs, such as the gipsy-moth, Cecropia moth, etc., and those of certain species like some of the Arctiid moths that feed upon a great variety of low plants.

4. Apparently chance associations that have become fixed, whereby diverse plants are utilized by oligophagous species. Secondarily polyphagous species show these in an exaggerated form. On account of their comparatively rare occurrence these seem to be analogous to structural mutations, although they appear to be strictly modifications of instinct. These associations are much more apt to occur in some groups (families and genera) than in others.

OPUNTIA CACTUS FROM WHICH WE GET OUR PRICKLY PEARS

A COLONY OF COCHINEAL BUGS ON A CACTUS PLANT

The Botanical Gardens of New York

An Unusually Fine Collection of Cacti and Other Interesting Plants

By H. A. Gleason

Assistant Director of the New York Botanical Garden

THE casual visitor in the huge greenhouses of the New York Botanical Garden hurries through them from one end to the other. He stops at one point to admire a plant with striking flowers or unusual foliage, at another to inspect a large tree and to follow its trunk as it extends high toward the dome, or again to marvel at some unusual specimen of the plant kingdom, unlike the plants of ordinary experience in its form or habit.

In such a cursory examination the visitor passes by without noticing some of the most curious and remarkable plants of the world, some of our most important economic species, and even many with delicate and charming flowers if they happen to be hidden under the foliage or appear near the summit of a tall stem.

Comparatively few visitors realize for example that the vanilla of commerce is produced from the fruit of an orchid or notice in the greenhouses the modest vine bearing that name. A zigzag stem ascends the trunk of a palm tree, bearing fleshy, glossy leaves at each angle and sending out long pendent aerial roots. Vanilla grows well under glass and reaches a length of ten feet or more, but it rarely flowers and the fruit is practically never seen in greenhouse cultivation.

STAPELIA BLOOMS WHICH RESEMBLE DECAYING FLESH IN COLOR AND ODOR

In another house a thrifty bushy shrub with elliptical leaves less than an inch long bears the label *Erythroxylon coca.* This is the famous coca plant, from which the well known drug cocaine is derived. Originally from the mountainous regions of northwestern South America, the Indians of its native land have for centuries used the dried leaves as a stimulant. A single fresh leaf when chewed causes a slight sense of numbness on the tongue from the small amount of cocaine which it contains.

Four sections of Conservatory Range 1 are devoted to succulents, including many types of plants from many countries, but all alike in inhabiting regions with limited water supply and in storing within their bodies a reserve supply of water for use during the arid seasons of the year. These include the fleshy-leaved Crassulas of Africa and Echeverias, native of the highlands of Mexico, the similar mesembryanthemums, of South Africa, agaves and yuccas of the American deserts, aloes and gasterias of Africa, and an unusually fine representation of the exclusively American cacti.

The collection of cacti, which is one of the most complete in the world, has been brought together during the last decade by Dr. N. L. Britton, director-in-chief of the

garden, to illustrate the monograph of the cactus family prepared by himself and Dr. J. N. Rose, of the Smithsonian Institution. Four general types will be distinguished at once by the layman, the cylindrical or columnar species of the cereus type, the hemispherical echinocactus type, the jointed opuntias, and the slender, branching, thornless species of Epiphyllum and Rhipsalis. Many of the latter, with their branched stems and white or colored berries. remind one of mistletoe, a resemblance which is increased by their habit of growing as epiphytes on trees. Some of these cacti are in bloom and others in fruit at practically every season of the year. Many species, of which the night-blooming cereus is an example, open their flowers only at night and their faded remains alone may be seen during the day.

A SPINELESS PRODUCT DEVELOPED BY LUTHER BURBANK

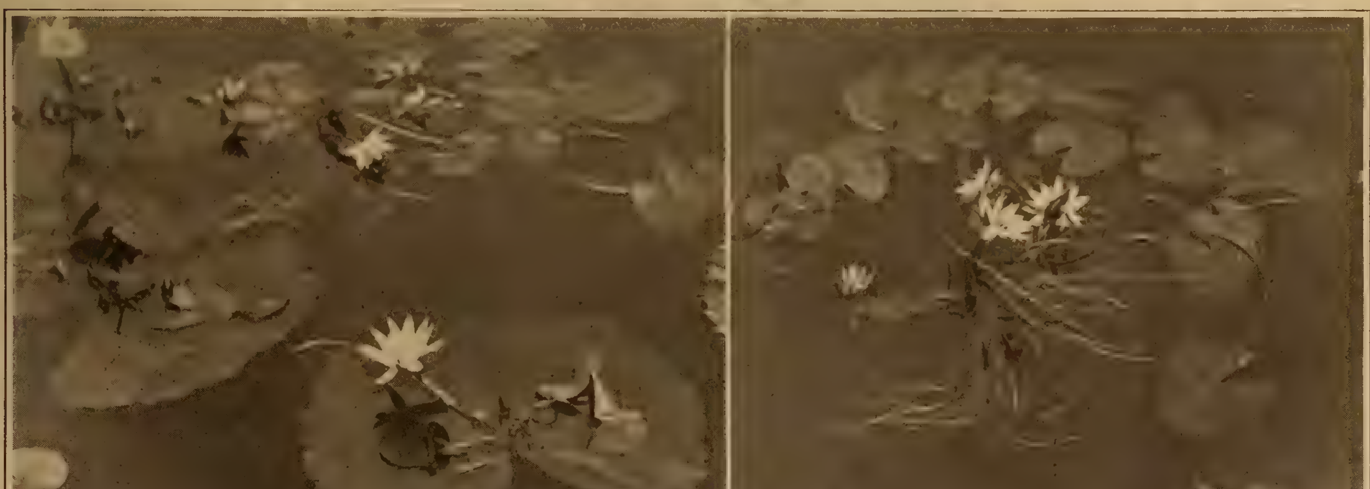
On some of the opuntia plants, the gardeners will point out the small insects from which the well known dye cochineal is produced.

Growing with the cacti are other desert plants, of which the euphorbias are so closely similar that the two are easily confused. The botanist, who can distinguish the two groups at a glance, calls this phenomenon evolutionary convergence. The layman might say that the euphorbias of the eastern hemisphere and the cacti of the western have been growing in the same hot dry desert climate for so many centuries that they have gradually assumed the same general structure and habits.

In an adjacent house are a number of small fleshy-stemmed plants two to six inches high, labeled stapelia. Few visitors notice their flowers, of which several are open at any time during the summer months. These are nearly two inches across, produced close to the ground, and of very complicated structure. They resemble decaying flesh in color, which is mottled brown and green, and in their repulsive carrion-like odor, and depend upon carrion-loving insects for their proper pollination.

In the aquatic house numerous adaptations to an aquatic environment are exhibited. These include submerged leaves, which are almost always finely dissected or narrow and strap-shaped; floating leaves, which are broad and flaccid and frequently provided with special tissue to render them buoyant; and floating stems provided with air chambers. An interesting method of propagation is exhibited by *Castalia Daubeniana*, in which a bud develops at the summit of the leaf-stalk, produces roots, leaves and flowers and eventually separating from the parent plant starts thereby on an independent career. In this house tall plants of sugar cane are to be seen along the wall, and in the shallow water is a healthy group of the Egyptian papyrus, with tall reed-like stems. With the present shortage of paper, attention is being directed anew to this plant, as a possible source of material for the manufacture of paper.

Proper maintenance of plants under greenhouse conditions requires specialized knowledge of many species and of their individual demands, as well as careful and continuous attention to their needs. Thermometers are provided in each section and are inspected at frequent intervals day and night. The proper temperature is maintained by regulating the steam, the ventilation, and the amount of sunlight; the latter being controlled by canvas shades which may be adjusted as needed. Insect pests must be combated continuously by spraying, by fumigation or by actually washing the leaves of the larger



CASTALIA DAUBENIANA—A CURIOUS FLOWER IN WHICH A BUD DEVELOPS AT THE SUMMIT OF THE LEAF STALK, PRODUCES ROOTS, LEAVES, AND FLOWERS AND EVENTUTALLY SEPARATES FROM THE PARENT PLANT

CAREFULLY WASHING OFF THE LEAVES OF THE LARGE PLANTS BY HAND TO KEEP THEM FREE OF DUST AND INSECT PESTS

EVEN THE DESERT-LOVING CACTI NEED CONSIDERABLE WATER AS WELL AS AN OCCASIONAL SPRINKLING WITH THE HOSE

plants. Even watering, simple as it seems, requires expert knowledge and is in fact one of the most particular pieces of work about the greenhouse. The skilled gardener taps the pot with his finger or gives a quick glance at the soil and knows whether they need water and how much to give them. Even the desert-loving cacti require considerable water, especially when their roots are confined in the narrow limits of a pot, and they appreciate an occasional sprinkling with the hose as well.

Propagation of new stock is done mostly in a separate greenhouse and the young plants are transferred to the public collection when they have reached a good size. One interesting method of propagation is usually in progress in the public houses, however, and attracts considerable attention. It is used chiefly for the larger trees and shrubs and is practised with great success on the India rubber and many other tropical species. An incision is made in the stem with a sharp knife, thereby interrupting the flow of sap and other food materials at that point. The stem is then wrapped with moss and kept constantly moist until new roots are formed at the cut and begin to appear through the moss.

THE GRACEFUL EGYPTIAN PAPYRUS WHOSE PITH WAS USED BY THE ANCIENTS TO PRODUCE A PAPER-LIKE WRITING MATERIAL

Then the moss is removed, the stem completely severed, and the upper portion with its new roots is set in a pot and continues its growth independently, while the old plant sends out new leaves and is actually improved by the operation.

THE OLIVE

THIS is the subject of a booklet just issued by the Research Laboratory of the Glass Container Association of America and deals very fully with the subject from the production of the olive to the method of preparing the fruit for market. It is held that the olive has been cultivated for more than four thousand years, and it is mentioned in the earliest literature. Its original home was probably in Asia Minor, being brought into Egypt during the Nineteenth Dynasty. Mummies, dating from the Twentieth to the Twenty-sixth Dynasty, have been found surrounded by olive leaves, and from Egypt its culture spread to northern Africa and thence to Greece and other parts of the Mediterranean. The tree is of slow growth, but if undisturbed persists for centuries and attains a great size. The tree is evergreen, flowers are small, and fruit of all degrees of ripeness are developed at the same time. The

TAKING A DRINK FROM THE "TRAVELLERS TREE" OF MADAGASCAR

A NOVEL SYSTEM OF OBTAINING NEW ROOTED SHOOTS FROM A RUBBER PLANT

fruit is peculiar in two respects, first, in that it contains in addition to the ordinary constituents of fruits an abundance of edible oil, and second, it contains a bitter substance which does not disappear on maturity, so that the fruit cannot be eaten at any stage of its development without preliminary treatment for the elimination of this substance. The method of treating the fruit varies in different countries. The old Romans not only removed the bitterness, but caused the olive to acquire various flavors through infusion in solutions containing aromatic substances. In removing the bitterness they were soaked in water, sometimes hot water being used, after which they were held in brine until wanted. One method called for the addition of roasted salt to the olives, after preliminary soaking in hot water, and then covering them with boiled wine or honey water to which were added fennel, mint, etc. Many recipes have been left by the ancients the preparations varying in time, strength of solutions, moisture, spices, etc. It is known that the Romans practised the use of lye solutions, sifted ashes being indicated as one of the ingredients.

Today nearly all the green olives used in the United States come from Spain, though a few are imported from Italy, Greece and France. They are hand-picked, cleaned, treated in the usual way with lye, and washed, during which process care is exercised to prevent them being exposed to the air to avoid discoloration. After grading for size they are stored in large casks of brine. The casks are exposed to the sun to favor fermentation, during which time the olives slowly change from deep green to golden. Ten per cent brine is used in the casks; but this weakens from seven to seven and one-half per cent during the curing period. The operation of stuffing consists in removing the pit by a pitting machine and filling the cavity with some other substance.

Most of our ripe olives originate in California where three pickings are made during the season in order to obtain fruit of equal ripeness. At the factory the fruit is first sorted, graded for size, and is then placed in an alkaline solution, usually sodium hydrate, the strength of which varies, but probably averages one and one-half per cent. At the end of six to eight hours this lye is drawn off, the olives exposed to the air to brown them by oxidation, and the operation repeated until an examination shows that the lye has penetrated to the pit. Clear water changed twice daily is now used until the lye and bitterness are removed, this requiring from four to eight days. The next treatment consists of a series of brine solutions, beginning with one per cent and increasing the strength at intervals of about two days until approximately four per cent is used. At this point they are ready to be put into glass cans and sealed.

Some packers allow the olive to remain in the weak brine long enough to produce an acid flavor by fermentation and others endeavor to retain the natural color rather than to induce oxidation. If it is intended to hold the olives in bulk the strength of the brine is increased until ten or twelve and one-half per cent is reached, the stronger solutions being necessary if they are to be carried through the summer.

To be sure the process as outlined is modified in practice to satisfy the conditions, taking into consideration varieties of fruit, temperature, etc. As the olives are packed the soft and defective ones are discarded and the containers are filled with three per cent brine at a temperature of 175 or 180°F. The air is then exhausted while the temperature is raised to 185° when the containers are sealed ready for processing. Processing consists in cooking in the bottle from fifty to sixty minutes, depending upon the size of the olive and the size of the container. 240°F. is reached in some factories. If a lower temperature is used the time is increased.

The history of the olive and the method of its preparation show no organisms, pathogenic to man, normally present, and hence if any are found they must come through local infection from the outside. Much research has been done by the scientific staff at the University of California along the developmental and preserving lines, and recently one of the staff has developed methods for treating the olive with aerated hot solutions which permit the preliminary treatment to be done in from three to six days instead of as many weeks, as formerly, and these methods promise to be of great economic value.

With reference to the poisonings which followed eating of ripe olives in certain cases last year a recent government report confirms the earlier finding as to the cause, but also points out that in such cases as have come to the notice of the investigators the condition of the unsafe olives were such as to give rise to an offensive odor upon opening the package such that the danger could be sensed by the average person who should refuse to serve any foodstuff that appears in any way contaminated or unfit for consumption.

The Dynamics of Plant Respiration*

A Study of the Various Forms of Energy Liberated by the Living Cell

By Camillo Acqua

The Botanical Institute, University of Rome

THE study of the intimate phenomena of the process of respiration—the various forms of energy liberated, their physiological significance—in short, the investigation of the mechanism of respiration, involves the examination of one of the most important problems in the entire realm of physiology—possibly, indeed, the most fundamental of all, since life is indissolubly connected with the process of breathing. Who does not know that all attempts to retain life in an organism, in the absence of the energy liberated through this process, by means of furnishing other forms of energy of outside origin, such as heat, light, and electricity, are vain? And yet respiration itself develops heat and other forms of energy which differ but little from those which we can furnish artificially to a living creature when we try to save it from asphyxia. . . . A very simple comparison will throw light upon this matter. If we wish to set in motion a steam engine, explosion motor, etc., the production of energy must take place in the machine itself. In the steam engine the coal must burn in the firebox; in the explosion motor the explosive mixture must burn in the explosion chamber. If the combustion is effected outside of itself the machine will not move, even if the same sort of fuel producing exactly the same forms of energy is consumed. And it is doubtless something of an analogous nature which must occur in the aggregates which constitute living matter. We usually define organisms as systems in which life is supported by an incessant production of energy furnished by an internal process solely, i. e., the process of respiration. This process in its widest significance is understood to be that which always results in the liberation of the energy required for supporting life, although the operation may be accomplished by various methods. Thus understood, respiration can be likewise defined as a process of *dynamogenesis*, but according to what we have said above the process in question must take place in the interior of those systems of energy which constitute the elementary particles of living matter; and if we designate these particles by the name of *plasmic micellae* we mean to indicate that the development of energy known as *dynamogenesis* must be intra-micellary in order for the micella to maintain itself in a living condition.

But if we attempt to investigate the nature of this intramicellary dynamogenesis and the method of its accomplishment, the problem presents a vexatious and baffling aspect in the present state of our knowledge. We know nothing concerning the constitution of a living micella, we know only that it may be considered to represent the simplest expression of life and that though it may thus be termed *elementary* it is none the less highly complex in nature. As to the real character of the energetic phenomena which take place within it, we are totally ignorant. And in any attempt to penetrate its mysteries we must seek an indirect method; when we try to throw some little light upon the obscure problem of the liberation of energy within the micella, we are obliged to study external phenomena and their relations. Similar indirect methods have been necessarily employed in the study of the intimate constitution of molecules and of atoms. The difficulties in studying the elementary particles of living matter are undoubtedly even more difficult than in the case of non-living matter, for we are still far from possessing a satisfactory physical chemistry of living matter. Hence we must content ourselves, at present, with merely preliminary researches.

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In this domain, as in so many others, the studying of plants must precede that of animals, since the former exhibit a simpler structural plan and since, furthermore, this examination constitutes an excellent preparation for that of the more complicated questions of general biology.

We will commence, therefore, by studying the phenomena which fall under our observation and investigating the external forms of energy liberated by respiration and the processes which contribute to this liberation. We shall likewise examine the nature of the materials employed to furnish energy and from the ensemble of these facts we shall seek to derive a point of support for some induction which will enable us to represent, in however preliminary and approximate a fashion, the mechanism of respiration.

That phenomenon of energy which is most closely connected with respiration is the production of heat. In only a very few cases do plants emit light; as for elecrtic energy, while it must be regarded as of considerable importance, it is not manifested as a direct consequence of the respiratory process, at any rate so far as we now know. With respect to mechanical energy plants exhibit continual examples, but it likewise is unknown to us as a direct manifestation of the process of respiration. Thermic energy, therefore, constitutes the most important form of energy developed in the course of this process. It is this which has chiefly engaged the attention of the men of science who have made research along this line.

While the production of heat is slight in most cases it is always easy to demonstrate, when we prevent its dispersion, and during periods of active vegetation. Sometimes, however, this thermogenesis may become very considerable: this is what happened in certain fermentations, and it also occurs in exceptional cases among the higher orders of plants. As an example of this we may quote the well known case of the *Arum Italicum* whose inflorescence terminates in a swollen organ which has been termed a "club" by reason of its form. In this instance the development of heat is so intense that it can be detected by means of mere contact with the hand. Coincident with this thermogenesis is a very active combustion of the carbohydrates contained in the club, which are consumed in the course of a few hours. The connection between physiologic combustion and the production of heat is, therefore, very evident in this case.

An endeavor has been made to discover the actual quantity of heat in calories given forth in such instances. Among those who have been particularly interested in this question I may mention Bonnier and Peirce. According to the latter the germination of peas occasions the production of 4.93 calories per day for each gram of weight; the figures given by Bonnier are even higher. But the researches of the last mentioned authority are of importance from another point of view. When complete oxygenated respiration is accomplished, i. e., when the carbohydrates undergo combustion until they have produced as final products water and carbonic anhydride, a quantitative analysis of this gas will give an idea of the amount of heat generated. M. Bonnier has endeavored to determine whether the estimated heat corresponds to that actually emitted. The problem is difficult since this very delicate investigation is more or less disturbed by the other processes which are constantly developing in the organism; nevertheless, M. Bonnier succeeded in determining in some cases that the heat emitted was less than that estimated, which indicates obviously, that a part of the energy produced in the respiratory dynamogenesis, instead of being transformed into heat, is retained, probably serving to support

the intimate energetic processes of the plasmic micellae. A new question then arose: What is represented by that part of the energy—the greatest part—which is manifested and dispersed in the form of heat? But all those who have studied this question are unanimous in the belief that it represents a loss except in a few special cases. According to this there must be a great dispersion of energy, analogous to that which takes place in ordinary steam engines, during the course of the physiologic combustion of living matter—at any rate in plants.

Another question which is likewise of great importance is that which concerns the materials which support this physiologic combustion, especially in the higher orders of plants. We cannot here enter into this question in detail but will confine ourselves to reminding the reader that the respiratory materials of the first order are furnished by glucose; there is no doubt of the fact that during physiologic combustion this substance is decomposed and oxidized either partially or completely, the terminal products in the latter case being water and carbonic anhydride. But glucose is a ternary body, composed of carbon, oxygen, and hydrogen; it cannot constitute living matter and we find it, in fact, in the cell, where it is often located in the vacuoles. And how then shall we reconcile this fact with the opinion that combustion must be produced in the interior of the energetic systems which characterize life, *i.e.*, those of intra-micellary nature? Two theories may be formulated with regard to this subject: either the molecules of glucose—and the same reasoning may be applied to all other bodies capable of acting as respiratory materials—must be connected in some manner with the micellae of living matter; or else the proteic substances which constitute living matter are capable of being decomposed so as to produce glucose as a respiratory substance, and of regenerating themselves later at the expense of some other glucose or other ternary bodies derived from the surrounding medium. According to this last hypothesis the glucose is the substance which burns, not because it takes a direct part in the combustion, but because it is a product of the destruction of the living matter. These theories have been extensively discussed and many arguments have been offered on each side; I will content myself with saying that either is possible and that either is in agreement with known facts as well as with the hypothesis of intramicellary respiration.

But at this point another question suggests itself: Is it necessary to admit that this conception is available for all the processes of dynamogenesis, including also the cases in which a process of abundance is concerned, such for example as the instance cited above of the generation of heat in the club of the Arum Italicum? This question, we believe, may be answered as follows: It is probable that in these cases a large part of the ternary bodies may undergo direct physiologic combustion; possibly it may be a case of an accessory respiratory process which might be termed *false respiration*. This process also might have its *raison d'être* in the special exigencies of the organism without being considered as strictly necessary nor as connected with the intimate energetics of the living micellae.

Thus we have arrived at the concept of a proper energy which is characteristic of living matter and which must consequently be quite distinct from the secondary processes which are met with in the organism. And just here we crave permission to make a brief digression.

Our present knowledge concerning molecules and atoms is of such a nature as greatly to facilitate the formation of a working idea of the constitution and energetics of a living micella. Since it has been discovered that the atom is not an indivisible corpuscle, but rather a little cosmos composed of other particles which in the present elementary condition of our knowledge must be considered as the smallest masses of matter which exist, it is possible to gain a concept of a special intra-atomic energy due to the movement of the individual corpuscles which compose the atom. Thomson, to whom we are indebted for certain brilliant speculations concerning this matter, designates this form of energy by the term *corpuscular* energy. If we afterward examine more complex aggregates, such as molecules, we find that they constitute other systems in which the atoms themselves function as units, i. e., in which they may be regarded as being reduced to so many particles of matter having the power of moving and of changing their position in the same manner that the planets move in unison with their train of satellites in the solar system. But molecules, too, are the seat of a special form of kinetic energy which may be termed in agreement with the ideas referred to above, *molecular temperature*. And just here we may quote Thomson once more to the effect that there probably exists no very close relation between these temperatures. Furthermore, we can conceive of molecules as being more or less complex until we arrive at those very complex ones which constitute the albuminoids, *i.e.*, those substances within which life is capable of being manifested. But in all these cases the same laws which govern the inorganic world also prevail.

Let us go one step further and consider the phenomenon of organization. Thanks to this the simple particles which we have designated as plasmic micellae acquire new properties; and by taking this last step we have crossed a definite line of demarkation and find ourselves concerned with new systems of a far more complex nature, in which phenomena must occur which can no longer be regarded as identical with those which take place in the interior of a molecule or of an atom. And here we find ourselves concerned with a special form of energy which is evolved in the interior of such systems and thereby supports life. And just as Thomson has called the kinetic energy of the atom *corpuscular temperature*, and the kinetic energy of the molecule, *molecular temperature*, we may give the name of *micellary temperature* to this special energy which is characteristic of the plasmic micellae, *i.e.*, of the elementary living particles. But since Nature exhibits an indisputable continuity in her laws, and since even when she seems to make an abrupt leap, she always presents certain bonds and connections between the different links in the great chain of her phenomena, we must seek to apply in the present case the same general concepts which have been of service in the study of other aggregates, especially of those constituting molecules and atoms. As we have said, Thomson points out that there probably exists no direct relation between *corpuscular and molecular* temperatures. These concern forms of energy which develop in systems which are not only different but largely independent of each other; we must endeavor to ascertain by analogy whether *micellary temperature* likewise represents an autonomous form of energy which is in great part independent of other forms and more particularly whether it is independent of *molecular temperature*, since molecules are the aggregates which most closely resemble living micellae. And since we are obliged to believe that there is a close connection between this molecular energy and the temperature revealed by the thermometer we must ask whether it will be possible to affirm the independence of the vital phenomena with respect to thermic energy. At first glance this question appears to demand a negative response; everyone knows how much influence temperature exerts in general upon the conditions of development which affect living creatures. But upon more profound examination we perceive that this judgment must be modified. We must not forget that during the vegetative period when the various processes of nutrition, growth, division, etc., attain a considerable degree of development, the respiratory process is accompanied by a number of other metabolic processes which depend, without doubt, upon external conditions, and which may also indirectly influence the respiratory process. In this case the phenomena observed are multiple, influencing each other and thus rendering it difficult to study the intimate nature of the process of dynamogenesis.

But there is another period in the course of which the various manifestations of the vegetative life are quiet, when

growth and cellular division are suspended, and when the chief process observable is that which possesses the power of maintaining life—namely, the process of respiration. This period, which is called the period of repose, obviously best lends itself to our investigations. We find at this time a great independence between the respiratory process and the other external forms of energy. The spores of bacteria are in general very resistant and sometimes support without injury a temperature considerably higher than 100° C. (212° F.). Seeds also are usually very resistant *both to heat and to cold;* thus Becquerel kept certain seeds at the temperature of liquid air for three weeks, and at that of liquid hydrogen for seventy-seven hours without destroying the germinative power in the great majority of them. And since it is impossible to conceive of life as existing without the respiratory process, we are obliged to conclude that the intra-micellary energy which we have termed *micellary temperature* also represents a form of energy which is quite distinct from other forms of energy and which is in great measure independent of them.

Thus, *corpuscular temperature, molecular temperature, and micellary temperature* represent the three forms of energy which exist in the interior of the three characteristic systems; namely, the atom, the molecule, and the living micella.

In the course of his brilliant speculations Thomson considers the cases in which, by reason of an effective elevation or an excessive diminution of intra-atomic energy, the system constituting the atom is unable to continue to exist, but is forced to disaggregate. . . . According to Thomson the constitution of the aggregate cannot be retained except when its internal energy is comprised between two limiting values which constitute its "critical values." But these concepts, which may be applied to aggregates of a higher order, i. e., to molecules, are likewise applicable by analogy to the plasmic micellae. Hence we are forced to believe that in order to maintain life the *micellary temperature* must be comprised between two extreme or limiting values. This enables us to give to the idea of death a definition which is new and possibly more exact than any hitherto proposed by saying that death occurs when the *micellary temperature* exceeds one of its limiting values. The action of certain poisons can thus be explained if we admit that they exert an influence upon the dynamogenesis by saying that they either exalt or depress the *micellary temperature.* And in the first of these two cases it can be readily understood that a partial or moderate exaltation may be favorable to the organism while an excessive exaltation may cause death. This would also explain the singular properties of certain toxic substances which act as excitants when administered in small doses, but produce death when the doses administered exceed a certain amount.

In this study I have sought to give a brief résumé of the dynamics of the respiratory process so far as we understand it at the present time (1915). Furthermore, I have attempted to apply certain general concepts derived from modern researches concerning the constitution of matter to the special case of matter which is organized and which is consequently living matter.

In attempts of this sort it is, of course, proper to proceed with caution, confining ourselves to general concepts. We are just beginning in fact to establish a physico-chemical science of organic matter and any hypothesis of too specific a character would run the risk of proving to be absurd. We need to make new researches and to discover other facts, other relationships, and other laws. Biology will not be able even to attempt the solution of its most difficult problems until it is possible to coördinate all the facts collected into a rational system and to utilize the assistance of definite mathematical laws. It is useful, none the less, to state the problem at the present time, so that we may, at least, indicate the direction in which future investigations must proceed.

New Theories and Methods of Vaccination

Collateral Immunity, Bacterio-therapy, Entero-therapy, and Vaccino-therapy

LITTLE did the famous Dr. Jenner foresee when he inoculated a patient for the first time with the pus of a bovine animal suffering from cowpox, as a means of protection against the dread scourge of smallpox, which at that time was not only killing thousands of people annually in nearly every country under the sun, but was hideously disfiguring hundreds of thousands of others, that he was lifting the edge of a curtain behind which was still concealed a knowledge of the causes and the cure of infectious diseases, which when fully revealed would confer enormous blessings upon all mankind.

Not only have widespread epidemics of smallpox become practically a thing of the past in civilized countries, by reason of the now nearly universal practice of compulsory vaccination of children, but similar methods have been successfully employed in case of many other devastating infectious diseases, such as yellow fever, typhoid and para-typhoid fever. One need not be very old to recall the shocking fact that during the Spanish War more soldiers were said to have died from typhoid fever while still in camps on American soil than were killed in battle among that part of the expeditionary force which succeeded in reaching Cuba. Contrast this with the fact that in the Great War recently ended typhoid fever was regarded as a menace not among the armies, whether in camp or at the front, whether in America or on French soil, but only among populations where for one reason or another, such as lack of supplies or inaccessibility it was impossible to vaccinate the people with the proper serums.

But great as was the boon conferred upon the human race by Jenner in checking the ravages of smallpox, it was not until Pasteur and Toussaint began their famous researches that vaccino-therapy or the treatment and prevention of infectious diseases by means of vaccines really entered into its kingdom. And even then there remained many people not only unconvinced of the efficacy of vaccination but actively hostile to it, even to such an extent that in many places anti-vaccination societies were formed. Pasteur and Toussaint extended the practise of vaccination to the two terrible diseases, anthrax and rabies, which while generally confined to animals are communicable to men and have counted many victims among the latter. Sir Almoth Wright, later, treated the bubonic plague and staphylococcic infection by vaccination.

But the researches of bacteriology during the present century and, particularly, during the war, have vastly extended not only the use of vaccination but also our very ideas as to the nature of its operation. It is the object of this article to set before the reader a brief account of the most recent theory and practise in the closely related subjects of bacterio-therapy and entero-therapy, as well as vaccino-therapy in general.

VACCINO-THERAPY

The practise of vaccination is based upon the proved fact that disease germs occasion in any organism which they infect certain reactions by which the body endeavors to defend itself against the invader. These reactions are characterized in part by the formation of certain specific substances which are capable of destroying the said microbes and, indeed, of destroying these in preference to others. These substances have received the name of anti-bodies. Even after the recovery from the infectious disease in question a number of these anti-bodies persist in the blood of the patient for varying

lengths of time, sometimes amounting to a number of years. It is this persistence of defensive anti-bodies in the blood of an individual, which confers upon him immunity from a fresh attack of the disease, and if the serum of blood thus highly charged with specific anti-bodies be introduced into the system of another person in danger of infection through exposure to the same disease, this latter individual will likewise acquire immunity by this vicarious method of vaccination. Obviously, too, an animal may be so prepared that its blood will contain a high percentage of the anti-bodies, characteristic of a given infectious disease. If the blood from this animal be drawn off—in quantities, of course, not so large as to injure the animal—the serum from it can be bottled and kept as a specific for the treatment of the disease in question or for its prevention. When such a serum is injected into the body of the victim of the same disease, the patient receives a welcome increase of the anti-bodies which he requires to combat the infection from which he is suffering. This form of vaccination is specifically known as sero-therapy, but while sero-therapy is of assistance in effecting a cure and gives an immediate protection, this protection is of short duration and is *passive* in character.

But when, on the other hand, instead of injecting the serum containing previously formed anti-bodies, the bacilli, which occasioned the disease, are themselves injected, a direct appeal is made to the latent defensive power of the organism itself. In other words, the body is forced to augment its resistant power and to intensify its means of struggle. In such a case the effect produced does not follow so quickly as when serum is employed but it is, on the other hand, far more energetic and more lasting. The protection or immunity thus attained is said to be *active*, since the organism has acquired it by its own efforts to produce a defensive reaction. This is the fundamental principle of vaccino-therapy.

It follows, furthermore, that if for one reason or another, the organism fails to react to the vaccine, the latter remains without efficacy. Naturally, too, if the vaccine itself is imperfect, as sometimes happens, and, therefore, incapable of producing the desired reaction, there is no result. As a matter of fact the results obtained by vaccino-therapy are quite variable, and this fact is used as a weapon by its opponents. Only by experiment can a discrimination be made between vaccines which are active and those which are ineffective.

THE TECHNIQUE OF VACCINATION

Technically speaking vaccination consists of introducing into the organism emulsions of the same microbes as those which cause the malady from which the patient is suffering or against which it is desired to obtain immunity. These injections are usually either subcutaneous, intra-muscular or intra-venous, in which case the introduced substance passes at once into the very tissues of the body. But as we shall see later the vaccine is sometimes introduced into the alimentary canal, either by the mouth or otherwise. Vaccines thus employed are known as entero-vaccines since they pass into the body not by direct injection but through absorption from the digestive tract. We shall recur to this subject later.

Vaccines must be given, of course, in definitely prescribed doses. These doses are dependent upon the number of microbes per cubic centimeter contained in the solution; the average dose is one containing 500,000,000, which corresponds to an approximate weight of 1 milligram of microbes. When highly active curative vaccines are employed, the average dose at the beginning is only one-tenth of this, *i.e.*, one containing 50,000,000. This initial dose is doubled, tripled, etc., in the following injections which should be made at intervals of not less than three or four days and not more than eight days. But the absolute number of microbes injected also depends upon their species and upon the case in question; it may be larger when preventive vaccination is employed. The lipo-vaccine and those made up with iodine are those which are best tolerated, while heated vaccines come next to these.

As we have said the injections may be either hypodermic, intra-muscular or intra-venous, but the latter form is rarely employed because of the violence of the reactions employed, which sometimes entails serious consequences. Usually the injction is the first form, *i.e.*, beneath the skin. The location chosen for persons not confined to bed is generally the lower spinal area, while for others the deltoid or sub-clavicular regions or else the flank is selected.

However, more recently some doctors, including Lumière and Danysz, have advised "mouth vaccination" by means of the so-called *entero-vaccines*. Particularly in typhoid fever, cholera, and certain forms of dysentery; these are advised mainly as preventive vaccines instead of curative vaccines. Dried vaccines are administered by the mouth; Dr. A. Fournier and Dr. Schwartz have obtained some interesting results by this method.

The reactions produced.—The injection of a vaccine causes both local and general reaction. Among the former are pain at that point of the skin (by the hypodermic method) where the vaccine is introduced, together with a redness and swelling which may last for two or three days; sometimes, too, the corresponding nerve ganglia also swell and become painful. The general reaction produced is more or less acute according to the method of injection employed. Its chief features are fever (39° C.), headache, discomfort, general stiffness, etc., lasting from twelve to twenty-four hours, but when two large doses are employed at the beginning or when the vaccine is injected into a vein very serious symptoms may appear, such as intense discomfort, shivering, syncope, high fever, etc.; such symptoms are, however, usually of short duration. Finally, kidney disturbances may appear (albuminuria, hematuria, urenia) and pulmonary troubles (the cough of tuberculosis).

Such results indicate that great caution must be used in employing vaccines for persons suffering with tuberculosis, acute nephritis, arterial-sclerosis, jaundice accompanied by a large liver, collapse, tachycardia, with myocarditis, ataxo-adynamic conditions, etc.

The more profound effects of injection.—The more profound reaction produced by the injection of a vaccine present two phases. The first of these which appears almost immediately is indicated by what is known to physicians as a *hemoclasic crisis;* this is marked by a decrease in a number of white corpuscles or leucocytes by a modification in the properties of the serum and in the coagulability of the plasma and by a diminution in the oxonic index.

This primary phase corresponds in part to what Dr. Wright terms the *negative phase*, during which the organism appears to exhibit less resistance to the infection. This phase is followed by the reactionary phase proper known as the diaphylactic stage; this is characterized by an increase in the number of leucocytes, which are at first poly-nuclear and afterward mono-nuclear, and also by a rise in the oxonic index and by a recovery of its normal composition on the part of the blood (48 hours on the average). At the same time the fever goes down, the gravest symptoms become milder, and the invalid feels considerably better. This latter phase lasts for several days and may even be definitive and followed by entire recovery. Consequently when curative vaccines are employed there is no use in renewing the injection until this latter phase has come to an end, whereupon if there is no recovery the more serious symptoms may show a fresh tendency to increasing gravity. In the same way it is important not to repeat the injection during the negative period, since this might increase the depression of the body's defensive powers, which occurs during this period. This is why there should always be a lapse of at least three or four days between the injections.

Preventive vaccines exhibit similar reactions but usually with less intensity; but it is none the less necessary to allow a proper lapse of time between the injections, in order to attain actual immunity (anti-typhic vaccination). Finally, it should be noted that these phenomena of reaction possess

merely the usual significations and depend not upon the nature of the vaccine but namely upon the mere fact of the introduction of foreign bodies into the tissues of the body which results in a hemoclasic crisis. This is why *all vaccines, no matter of what nature, produce reactions of the same kind.*

Entero-vaccines.—In most infections which have their origin in the intestines, such as typhoid and para-typhoid, fever, cholera, coli-bacillosis, etc., the disease occurs because the pathogenic microbe have been incompletely digested by the digestive juices; those which escape pass into the circulation where, acting as anti-gene, they produce the various reactions which constitute the symptoms of the disease. The manifestation of the disease is thought by Danysz and some other authorities to be due to chemical combination within the body, but a more modern view which is the one held by Dr. J. Laumonier, to whom the writer is indebted for much of the material in this article, is that the symptoms of the disease are due to a struggle between the colloids of the organism and the foreign colloids suddenly introduced into their midst.

But it is a well known fact that by methodical training, the secretions of the stomach and the intestines can be educated, so to speak, so that they will be capable of completely digesting substances which usually they attack only slightly or not at all; a well known example of this is that fowls may be trained to eat meat while dogs and other carniverous animals can be trained to digest bread and other vegetable food. This has suggested the theory that if susceptible individuals could be dosed systematically with cultures of the bacilli which produce intestinal infection, they might thus gradually acquire immunity to these infections both because the alimentary canal has been gradually accustomed to digest such bacilli, and because the defensive reactions of the body have been augmented.

From this point of view, of course, entero-vaccination is purely preventive. But the method has been extended to cases of disease where the patient is too feeble, from extreme youth, old age, or a chronic malady, to support the more violent reactions of ordinary vaccination.

In 1912 Courmont and Rochaix first employed stock vaccines of Eberth bacilli which had been sterilized by heat in enemas for typhoid fever; they thus obtained very encouraging results and notably a more rapid subsidence of the fever defervescence. Later Lumière and Chevrotier advised a polyvaccine composed of Eberth bacilli and para-pythic bacilli, sterilized and dried in the form of keratin pills administered by the mouth as a cure, but chiefly as a preventive for cases of para-typhoid fever and dithien-entry. During the war L. Fournier made use of liquid culture of the Eberth bacilli and of the para-pythic bacilli A and B, sterilized at 100° C., and either swallowed in a little sweetened water or else administered in enemas. In many cases this was found to have a very favorable action causing the fever to disappear and the disease to run its course more quickly. Finally, Danysz recommended entero-vaccination chiefly as a preventive in cholera and infections due to coli-bacilli.

BACTERIO-THERAPY

The comparatively new treatment known as bacteriotherapy is all too frequently considered a synonym for vaccino-therapy; since this is incorrect, let us at once define the former; whereas the latter term is very inclusive comprising all the methods by which any sort of microbes are employed as curative agents, bacterial therapy signifies specifically the treatment of certain infectious maladies by means of microbes different from those which have caused the said maladies. The English physician, Dr. Wright, who was one of the first to make a study of this process, soon observed that the microbes employed act according to a different mechanism in the two cases. When a patient suffering from a staphylococcic infection has a culture of the same bacilli injected into his system, the result is to reinforce the natural defences of the body against the staphylococci which have invaded it, and against these chiefly, whereas, if a typhic patient is injected with cultures of pyoscyanic germs its defences are not reinforced against the Eberth bacillus in particular, but merely in a general and non-specific manner against a state of infection; hence the distinction now generally accepted by advanced authorities between vaccinal therapy which provides immunity against a given microbe and against it alone, and bacteriotherapy which furnishes no specific immunity but causes an ordinary increase of intensity in diaphylactic processes.

As stated in an earlier portion of this article these results are dependent essentially upon the fact that the introduction into the organism of foreign bodies increases the number of leucosites, and intensifies the activity of the bodily secretions, to the end that the intruding bodies are finally destroyed. It must be remembered that these effects do not depend upon the actual microbes themselves, considered as microbes, since they are capable of being produced by very different bodies, such as sugar, peptone, the various serums, colloidal metals, etc. This very new branch of science is still being studied. When first employed microbes were taken which were supposed to be antagonistic to those which it was desired to combat. Thus yeasts were recommended for boils and carbuncles and staphylococcic affections in general and lactic and paralactic bacilli for intestinal affection, but Dr. Wright, continuing his researches that the inoculations of a vaccine designed to combat the bubonic plague also combated eczema and blennorhagia, while anti-typhic inoculations combated malaria.

Collateral immunity.—Wright, therefore, concluded that besides their specific action vaccines possess a general protecting action to which he has given the name of "collateral immunization." This new idea is being widely studied not only in England but in this country and in France. Some of the principal effects observed are as follows:

Injections of anti-typhic vaccine have been found to cause improvement in certain cases of articular rheumatism, eczema and tuberculous lupus; reciprocally sterilized cultures of pyocyanic and coli bacilli and of coli bacilli have produced favorable results in typhoid fever as have also cultures of *proteus*. The English make use of cultures of staphylocci for pneumonia, while in America sterilized Eberth cultures are used to fight the same disease.

Nicole and Blaizot have even recommended a vaccine intended to combat tuberculosis; this is an anti-staphylococcic vaccine. Cépède recommends for the same purpose a vaccine composed of streptococci, staphylococci, pneuomococci and entereococci. However, these tuberculosis vaccines are directed rather against the secondary infection of tubercular lesions than against the tubercular bacillus itself. Finally, Delbet and Robineau employ a complex vaccine to combat all infections which are accompanied by suppuration, such as anthrax, abscesses, and infected wounds or burns. This vaccine is prepared by "aging" the culture, and in consequence of this the products of autolysis are concerned in its activity. The technic of bacterial-therapy is the same as for vaccinotherapy described above.

WARM FEET IN BED

QUITE apart from the comfort of the matter it is recognized that on health grounds it is important to have warm feet in bed. A British physician has described a novel method of securing warmth for the feet. A paper tube about three feet in length is prepared by rolling a big sheet and pasting the edges together. When the person is in bed this is pushed down under the clothes toward the feet. The upper end of the tube is held close to the mouth and the following method in breathing is adopted. The fresh air is inhaled through the nose and the exhalation is made through the mouth down the tube. As a result there is a current of warm air continuously being poured into the bed. In quite a short while the feet become comfortably warm and the tube may then be discarded.—By *S. Leonard Bastin.*

GENERAL VIEW OF THE MAIN HALL OF THE PHYSIOLOGICAL LABORATORY OF THE FRENCH ARMY AT JOINVILLE
(Note the Demeny double conformator at the extreme left)

The Cult of the Sound Body

Apparatus Employed in Modern Physiological Laboratories to Test Physical Development

By T. V. Davidson

ONE of the vital lessons pressed home by the war in every country engaged therein, was the unsuspected and in some cases even appalling percentage of physical defects found in the youth of the populace, and that at the very age when they should be in their physical prime. In spite of the fact that the modern development of machinery has rendered the actual physical prowess, which is all important, in the hand to hand fights among savages and primitive peoples less imperative, it was early recognized that no matter how big the caliber of the gun, how long its range, it is, in the last analysis, the man behind the gun that counts. In certain branches of modern warfare, indeed, the faultless working of the human machine is of even more vital import than in the Wars of the Roses. While the aviator, for instance, may require no great strength of muscle, it is imperative that he should possess a perfect coördination of muscle and a perfect response of muscle to nervous impulses; again, the proper functioning of his sense of equilibrium may at any moment be a matter of life and death. These things are so obvious that experimental tests for candidates for aviators were among the first to be introduced in the various armies engaged in the recent great struggle. Evidently, too, there are certain physical defects making it inadvisable for their possessor to undertake diving or submarine work.

Muscular Training.—It is no longer thought desirable to develop one set of muscles enormously at the expense of others and, indeed, this practise frequently proves very harmful in later life, as in the case of athletes whose college activities are suddenly changed for the more sedentary pursuits of a business or professional career. Yet more and more it is being realized that a well-balanced development of the muscles of the entire body exerts a favorable reaction upon the health and vigor of the individual, and this applies not only to his external, physical organism, but to the internal organs since judicious muscular exercise promotes at once the circulation of the blood and the excretion of waste matter from the skin and the other organs whose functions it is to get rid of the ashes and clinkers, so to speak, which would otherwise clog the engine.

But this is not all—no less an authority than the distinguished psychologist, Dr. G. Stanley Hall, makes the following significant statement in his remarkable work entitled "Morale," a word by the way which he defines as "the supreme standard of life and conduct":

"The muscles are nearly half the body weight. *They are the organs of the will which has done everything man has accomplished,* and if they are kept at concert pitch the chasm between knowing and doing which is often so fatal is in a measure closed.

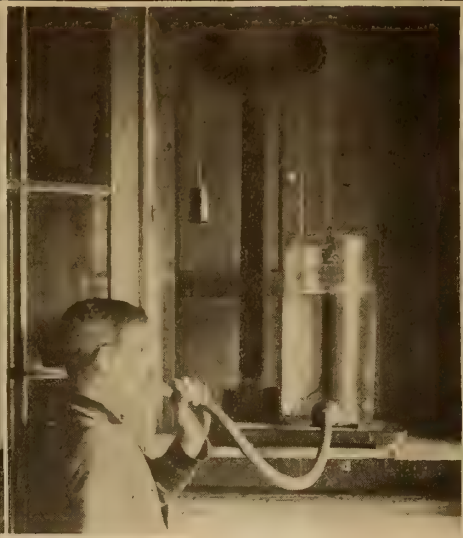
"There is no better way of strengthening all that class of activities which are ascribed to the will than by cultivating muscle."

These weighty words are worth being pondered seriously and one of their clearest implications is that each group or set of muscles must be studied separately and subjected to the special training it requires. Moreover, the various systems of muscles must be studied in relation to each other and, if necessary, made to coördinate harmoniously. The muscles required by the typist and the dancer are far apart, to be sure, and at first thought those required by the pedestrian and the oarsman seem equally unrelated. And yet when the writer was a student at Cornell, it was a common saying that the superior ability of the crew was due not only to the efficient training of the veteran coach, and the steady practise on the blue water of Lake Cayuga, but largely to the fact that the toilsome climb up the long hill from the lake to the campus developed the leg muscles and backs of the men so as to give them greater staying power than their rivals.

POST WAR SCHOOLS FOR PHYSICAL TRAINING

So marvellous was the improvement in the physical condition of many recruits, from the physical training given them before they were considered fit to go into action, that it was a matter of common remark that the erect, well set up troops who had undergone such intensive training could hardly be recognized as the same flat-chested, round-shouldered, spindle-shanked recruits who had come slouching into camp a few months before. It is encouraging to note that this sort of special training has not been dropped with the cessation of hostilities. The work is developing, indeed, on a larger scale than before, and it is the purpose of this article to describe some of the special apparatus devised, particularly in France and in Germany, for testing the physical condition of the applicants for training.

VERDIN SPIROMETER FOR TESTING THE CAPACITY OF THE LUNGS



INSTRUMENT FOR MEASURING THE VOLUME OF AIR EXHALED

MODEL ILLUSTRATING INFLATION OF THE RIBS DURING INHALATION

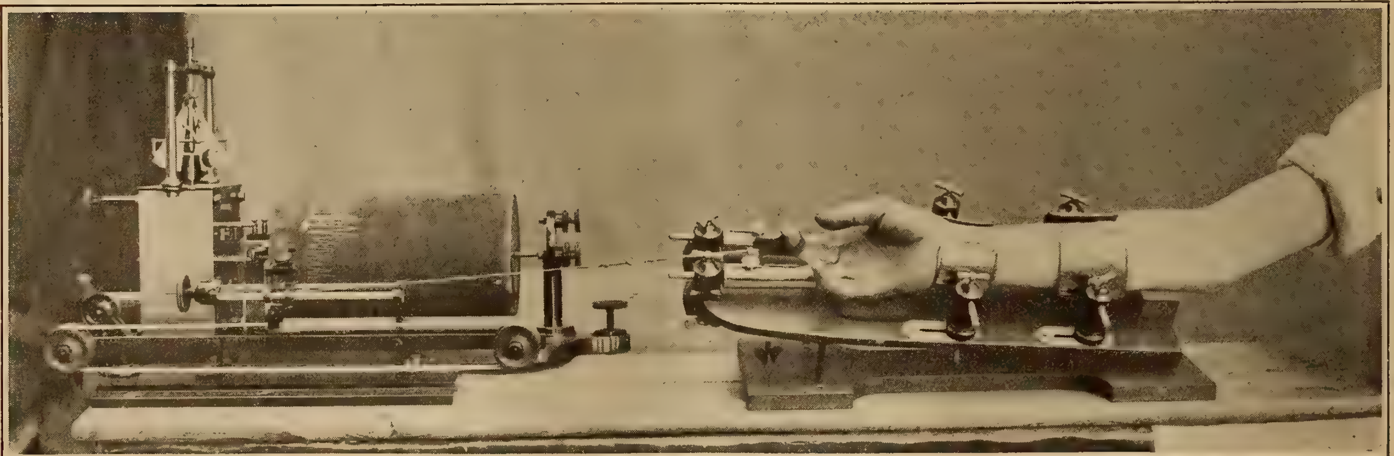
One of the most interesting of these schools is the physiological laboratory of the French army newly established in the quarters left vacant by the Canadian army in the forest of Vincennes and known as the *Ecole Joinville.* This laboratory is a sort of annex for scientific experimental work attached to the normal school of gymnastics and fencing at Joinville (Seine). At its head is Dr. Boigey, physician in chief. It contains an extensive assortment of apparatus including the recorders and meters employed in physiology and in psychology for such various purposes as the observation of muscular contraction of the circulation of the blood, of the respiratory process, and instruments for measuring the form of the body, both at rest and in motion. It also includes a chemical laboratory and studios for photography and chromophotography. Most of the apparatus employed has been specially invented either by Dr. Boigey or by Professor Demeny of the *Course of Physical Education* of the City of Paris.

Measurements of the chest are made by means of a special compass with ivory points; one of these points is on the end of one of the legs while the other forms the end of a rod attached to a spring-pressed pointer which can be moved at will over a graduated index. Thanks to this arrangement the compass can readily be withdrawn without opening it and without wounding the subject of the examination; the elasticity of the spring keeps the rod provided with the ivory button constantly in contact with the chest of the subject while at the same time allowing his respiratory action to proceed without interference. Thus the path of the rod measures the increase in diameter of the thorax during inspiration and its variations can be readily recorded by means of a Marey drum.

In order to obtain all the measurements of the body with the utmost possible degree of precision, Professor Demeny has contrived a "*universal double conformator*" by means of which there can be inscribed upon a sheet of paper the various sections of the trunk in a vertical plane passing through the spinal column and in horizontal plane, taken at different heights of the thoracic cavity. The essential members of the apparatus consist of the series of wooden pins which are movable about rigid axes and which are capable of being fastened either horizontally or vertically upon a framework. The ends of the pins are placed in contact with the spine or the portion of the body to be profiled and are then fixed firmly by means of a clamp. Since the latter can be detached from its vertical support, it is easy to copy on paper the profile indicated by the pins.

By means of two series of pins held parallel to each other, the form of the section of the trunk or the anterior, posterior, and lateral profiles can be measured very rapidly. In order to determine the vertical section of the trunk, two rods bearing pins are attached to two vertical uprights; to obtain a horizontal section of the chest, four rods provided with pins and attached to a frame within which the subject of the experiment is placed, are employed. This frame may be adjusted vertically to any height desired.

Among other interesting data the Demeny conformator shows instantly, without requiring previous calculations, any



MOSSO'S ERGOGRAPH FOR MEASURING AND RECORDING FATIGUE OF THE FINGERS

TESTING STRENGTH OF THE ARMS WITH A BLOCH STHENOMETER

STUDYING MUSCULAR SENSE OF THE IDEA OF RESISTANCE

MEASURING STRENGTH OF THE LOINS WITH THE STHENOMETER

defect of symmetry in the structure of the body, such, for example, as a difference in height between the shoulders and hips or the ankles and the shoulder blades, as well as the normal or pathological curvature, as the case may be, of the spine, etc.

The Rachigraph or Profilograph.—This instrument which is especially designed to indicate the outline of the spinal column consists of a carriage movable in a vertical guide-way, by the side of which the patient stands, which bears a rod that is brought back to position by a spring and by a jointed parallelogram. In order to perform the experiment the observer after having placed the back of the subject against the vertical guide-way and attached a pencil to the end of the rod connected with the parallelogram, moves the carriage from bottom to top; this causes the curve of the spine to be recorded in life size dimensions upon the sheet of paper.

Another apparatus makes records of sections of the body taken in a vertical plane. The subject is held in a rigid position by means of a system of solid supports, while two rods mounted upon rollers outline the depth of his body, the record being inscribed upon a sheet of paper.

Spirometer.—To discover the volume of air taken into the lungs during a deep inspiration, a very simple spirometer is used at Joinville. It consists of a bell-glass balanced by a counter-weight and immersed in a cylinder three quarters full of water. The subject exhales the air through a rubber tube with a glass mouthpiece, which runs to the lower tubulure of the spirometic vessel. The section of this tube is exactly equal to that of the trachea so that there will be no resistance to the air proceeding from the lungs of the subject and no alteration of the respiratory rhythm. The air exhaled causes the internal pressure to be increased and the amount of the increase is shown by a manometer. Furthermore, if care is taken to graduate the manometer beforehand by injecting successively 1, 2, 3, 4, 5, etc., liters of air and marking the corresponding level of the water for each, the volume of air injected can be read off at once. An improved apparatus known as the *Verdin spirometer* is also employed. As shown in the photograph this apparatus resembles our familiar gas meter.

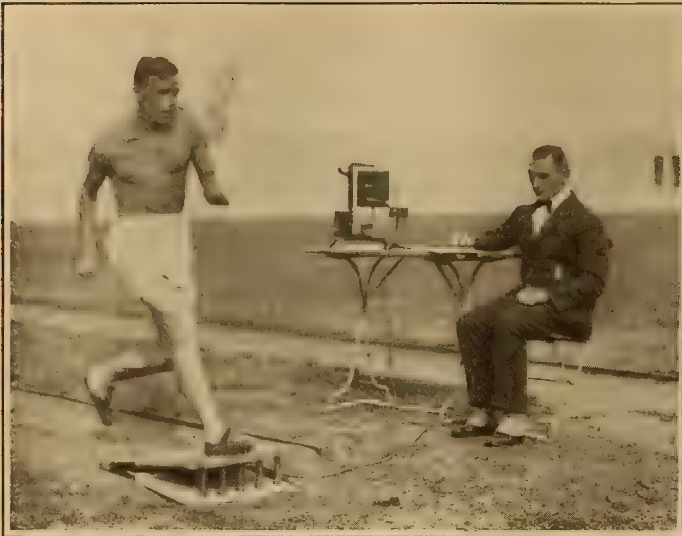
The Mosso Ergograph.—This instrument which is too well known to require description is employed to record variations in muscular work performed.

The Bloch's Sthenometer.—By means of this apparatus the strength of the loins and of the arms is readily found.

Chronophotography.—The mechanism of the movements made by muscles in action is studied by means of ordinary photography and motion pictures, and in more detail by chronophotography. An extended account of this latter process, especially as applied to the movements of men crippled in the war, was published in this magazine in the issue of January, 1920. Its value consists, of course, in the fact that it enables the physical instructor in charge to study the physiological effect of various exercises upon men with artificial limbs.

The Time Required for Response to a Stimulus.—One of Dr. Boigey's valuable inventions is a device similar to the

DR. BOIGEY'S METHOD OF DETERMINING THE TIME INTERVAL REQUIRED FOR RESPONSE TO A STIMULUS



MEASURING PRESSURES AT THE TAKE-OFF OF A RUNNING LONG JUMP

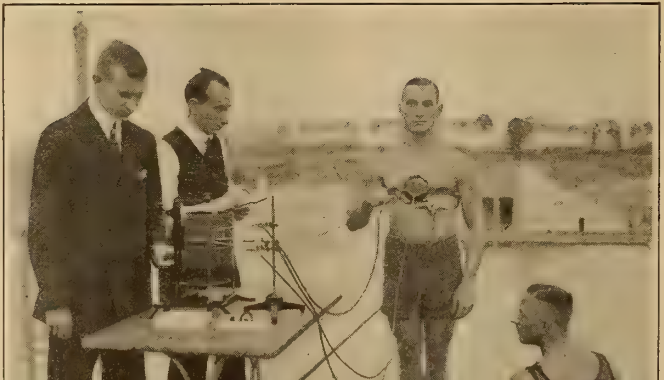
A GERMAN ATHLETE BEING SUBJECTED TO A SIMPLE FATIGUE TEST

Arsonval apparatus for measuring psycho-motor reactions. It is employed for measuring the interval of time required for response to any stimulus. The examiner touches the index finger of the subject's left hand with one of his own fingers and the subject responds with the forefinger of his right hand. He does this by placing each of his two forefingers upon wooden keys which press upon a rubber tube connected with a Marey recording cylinder.

The Study of the Muscular Sense.—To study the muscular sense Dr. Boigey proceeds from two starting points—the idea of *resistance* and the idea of *position.* In the first case the subject, whose eyes are bandaged, is seated at a short distance from the examining physiologist, who attaches to his index finger a thread or wire to which is fastened a weight of from 200 to 500 grams; to this he adds smaller copper weights of 10 or 15 grams each. The subject is required to estimate the amount of weight added or subtracted. If he makes a mistake this indicates either fatigue or neuro-motor disturbances.

In order to test the muscular sense by means of a change of position Dr. Boigey has prepared a wall chart upon which are drawn lines radiating from a common center and with their ends terminating at intervals of 15 centimeters. The subject, whose eyes are again bandaged, is placed so that his shoulder corresponds approximately to the center from which the radiating lines start; the examiner then lifts the arm of the subject to a given initial position which he marks with his hand. He next orders the subject to lower his arm to his thigh and then return it to its former position. In practice the subject most often brings his arm to rest 10 or 15 centimeters short of its initial position. (See frontispiece.)

Similar tests are being applied in German schools and we include among our illustrations three obtained from such an institution. In one the subject, who is clad in a bathing suit, is shown undergoing examination for nervousness or dizziness. He is required to stand at the edge of a platform about 12 feet above a swimming pool. Time curves are obtained which give an excellent idea of the character of the respiration and of the pulse and heart beat besides indicating indirectly the nervous condition and the morale with respect to courage and daring.



TESTING A SUBJECT FOR NERVOUSNESS OR DIZZINESS

Another picture shows a scientific examination of a running long jump. The pressure produced by the act of jumping off is indicated by curves which are afterwards critically compared so as to enable students to correct the faults revealed by the apparatus.

Still another picture also taken at what is ambitiously called "the world's first high school of physical culture," shows a simple fatigue test being given by the director of the psychological laboratories.

THE EBULLIOSCOPE AND THE CRYOSCOPE

AT a meeting of the New York Section of the American Chemical Society held on June 11th, two pieces of apparatus were exhibited which attracted much attention from the audience. The first of these is an improved apparatus for determining the amount of alcohol in "temperance" drinks and beverages made from cereals. This device is known as the ebullioscope because the method employed depends upon an accurate determination of the boiling point of liquids. Complicated forms of this have long been used but the present type is an improvement meant chiefly for the use of brewers producing malt drinks containing less than one-half of one per cent of alcohol. It has been found useful by inspectors of the Revenue Bureau in field work whenever quick tests, requiring not more than a quarter of an hour, are thought sufficient.

The cryoscope depends upon the opposite principle of a determination of the freezing point. It is a well-known fact that various liquids have various densities at the freezing point. For example, if milk has been watered the temperature at which it freezes is different from that at which pure milk freezes, and this difference is registered by the cryoscope. This instrument was developed by Dr. Hortvet of the Minnesota State Dairy and Food Commission.

Is Oxygen Necessary for Animal Existence?*

Formation of Carbon-Dioxide Only One of a Number of Possible Energy Producing Processes

By Dr. O. Krummacher

SINCE Lavoisier recognized the fact that the decomposition which takes place in the bodies of animals must be regarded as a process of combustion, the view has been held until quite recently, at any rate, that oxygen is indispensable to life. It is the object of the following article to discuss the extent to which this theory still holds good, and what modifications it may be subject to.

Lavoisier believed the lungs to be the hearthstone of the body upon which the combustion of fuel takes place. He held the view that the oxygen drawn into the lungs at once liberates its energy at this very spot. It was not till some time later that we learned that the pulmonary artery, the blood vessel which carries the blood to the lungs, already contains large quantities of carbon-dioxide, and that consequently this gas is not first produced in the lungs. It can also be demonstrated that the oxygen which is breathed in is not consumed in the lungs, since the pulmonary veins which carry the blood away from the lungs actually contain larger quantities of oxygen than do the pulmonary arteries. The blood, therefore, absorbs oxygen during its passage through the lungs, while as it flows through the rest of the body it becomes steadily poorer in oxygen and richer in carbon-dioxide. Somewhere in the organism, therefore, carbon must undergo combustion to form carbon-dioxide, *but just where does this occur?* It is natural to assume that the processes of combustion take place in the blood, but this concept was bitterly opposed in his day by the distinguished physiologist, Carl Ludwig.

But Ludwig was lacking in a faculty for comparative investigation. He once remarked to his pupil, Gaule: "When a man has once located himself comfortably on his own floor of the building, what does it matter to him what goes on in the lower stories." Of course, such a sagacious limitation as these words imply, may be quite in place as regards certain special problems, but when we are concerned with the most important characteristic of life, that of metabolism, we dare not close our eyes to those organisms which are lower in the scale than ourselves. The imperativeness of this view has been emphasized by no one more strongly than by Pflüger. In a noteworthy memoir, published in 1874, he collated the most important reason for the view that the physiological combustion does not take place in the fluids of the body, in the blood and the lymph, but in the tissues, in the cells and collections of cells, i.e., in the muscles, glands, and nerves. It will suffice in this place to cite the most striking bases of his views.

Lower Animals.—Many of the lower animals, which have been proved indisputably to form carbon-dioxide, have, in general, no blood at all, while in others, as in the insects, the function of the blood appears to be merely the conveyance of nutrition without any connection with respiration. It is far oftener the case among these that the entire body is penetrated by a system of delicate air tubes, whose most minute branches *directly penetrate the cells.*

Vertebrates.—And even among vertebrate animals physiological combustion is not indispensably associated with the presence of the blood: thus in the frog the blood may be replaced by a dilute solution of ordinary cooking salt without the formation of carbon-dioxide being diminished thereby. Finally, it can also be demonstrated that organs which have been separated from the body consume oxygen and form carbon-dioxide, although they are no longer supplied with blood, this being the case, especially in excised frog muscles. These instances, to which many more might be added, may have an application; this much, at any rate, is undoubtedly true—the seat of physiological combustion is to be found, not in the blood, but in the tissues.

On the other hand, it is a proved fact that the living body has no available energy except that of chemical tension; still, it by no means follows from this that the processes which liberate vital energy must necessarily be combustion processes.

Is Oxygen Indispensable to Life?—The question at once arises, therefore, as to whether oxygen is absolutely necessary to vital existence. The indispensability of this element was long considered a definitely proved fact, until investigators first came across *living organisms in the form of yeast cells, which flourish even when entirely deprived of oxygen.* It was learned later that there are numberless other bacteria which not only dispense with oxygen, but to whom oxygen is actually fatal. We are, to be sure, concerned here with very lowly organisms, which originally were numbered among the plants; but gradually similar observations with regard to animals were made in increasing numbers. Pflüger demonstrated that frogs are capable of living as much as 17 hours in pure nitrogen and that during the first 6 hours the formation of carbon-dioxide was hardly diminished. However, it must be admitted that they finally perished through the lack of oxygen. On the other hand, the worms which live in the intestines of many mammals have in general no need of oxygen, the animal of this sort most adapted for experiment is the ordinary abdominal round worm, *Ascaris.* After Bunge had first become convinced that these worms liberate carbon-dioxide which certainly is not formed by combustion, Weinland succeeded in determining their metabolism with more precision. These creatures derive the greater part of their energy from glycogen, which is usually found stored up in their bodies in large quantities. Through the operation of their vital activities this nitrogen is decomposed into carbon-dioxide and some of the lower fatty acids, chiefly valerian acids. The whole process presents great similarity to that of alcoholic fermentation, which likewise takes place without the aid of atmospheric oxygen. I have employed myself, together with Dr. Schulte, in the endeavor to explain this interesting process with respect to its phenomena of energy, but in the present article I shall refrain from going into details with respect to these experiments.

Life Without Oxygen.—It is thus demonstrated to be a fact that vital activity without oxygen is entirely possible, not only in one-celled organisms but also in animals with well-developed systems of muscles and nerves; and this is true, not merely as an exceptional instance, in the laboratory of the physiologist, but also under entirely natural conditions. It is, of course, a deeply rooted principle in human nature to hang on to old beliefs as long as possible. And when a thing which according to theory is quite inadmissible, cannot be explained, the first endeavor of mankind to find a path around the obstacle is to declare it to be a latent phenomenon.

Thus, there developed the hypothesis of the storing up of oxygen in a concealed or latent form, whose principle features were announced by Engelmann as early as 1868, upon the basis of his studies of the ciliated cells of lower animals, but which did not obtain its final form until stated by M. Verworn and his disciples.

According to this concept oxygen first meets with a nitrogenous compound of the living tissue. And from this compound, the *biogen,* there is then split off only the precise amount of oxygen required for the needs of the moment, thus a temporary life without any supply of oxygen is quite compre-

*Translated for the *Scientific American Monthly* from *Die Umshau* (Frankfurt) for September 18, 1920.

hensible, but not a continued life such as we find in intestinal parasites. It should be noted, however, that at the time when Verworn announced his *biogen theory* the peculiar conditions which characterize the life of the animals which dwell in the intestines had been subjected to scarcely any research.

But it may be asked whether the oxygen which is a component of carbohydrates, fats or albumins might not take over the rôle of atmospheric oxygen. When in the process of fermentation grape sugar is decomposed into alcohol and carbon-dioxide, it is acknowledged that the oxygen held fast in the carbon dioxide is derived from the grape sugar, and yet in this case also the carbon-dioxide is transformed into the highest stage of oxidation, so that the expression has been applied to it of intramolecular oxidation. The case is quite similar with the above-mentioned splitting off of carbon dioxide from the glycogen in the body of the *Ascaris*. Whereas, therefore, in the earlier views of the matter oxygen was considered unconditionally requisite for this vital process, but according to the newest investigations can be dispensed with, yet men of science have sought to reconcile these opposite views by the doctrine of *intra-molecular oxidation*.

Intra-molecular Oxidation.—At present the term *Intramolecular respiration* is commonly used instead of the above expression, especially among botanists, who, in contradiction to students of animal physiology, signify by the word respiration not only the exchange of gases which takes place in the body, but also those combustion processes which take place in the living organism. However, this attempt to reconcile these contrary ideas hardly bears the test of a closer examination. It is by no means true in general that when atmospheric oxygen is lacking, carbon-dioxide is nevertheless produced. There are, indeed, certain living organisms, such as a certain kind of lactic bacteria, which as a general thing do not form carbon-dioxide, but exist rather by means of that energy which is liberated from the grape sugar in lactic acid, according to the terms of the following equation:

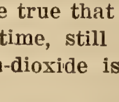
$$C_6H_{12}O_6 = 2C_3H_6O_3$$

or one molecule of grape sugar = two melecules of lactic acid. And while it may be true that other metabolic processes take place at the same time, still it has been indisputably demonstrated that carbon-dioxide is never produced by this sort of bacteria.

It should be recalled further that carbon-dioxide is not the only element which plays a part in the liberation of energy: We need only call to mind the *sulfur bacteria* whose need of calories is supplied essentially by the combustion of sulfuretted hydrogen. The foregoing considerations indicate that the *formation of carbon-dioxide from carbon is only one among a number of possible processes for the creation of energy in the living organism and is by no means an essential characteristic of life.*

If we acknowledge this to be true and consequently refuse to accord to carbon-dioxide a peculiarly privileged position above that of other elements in the great household of living organisms, then it is obviously without any special significance to make a point of talking of intra-molecular oxidation in the splitting off of carbon-dioxide from the organic molecule; for if the oxygen changes its position within the molecule, then naturally the oxidation of the one group must go hand in hand with the reduction of another group, as may be readily seen by the following example:

Ortho-nitro-benz-aldehyde is transformed under the influence of light into nitroso-benzoë-acid according to the following formula:



in which the aldehyde group is oxidized and the nitro group reduced.

This connection is, it must be confessed, not so readily obvious in the phenomena of fermentation; the butyric acid fermentation alone affords a striking example, in that carbon-dioxide is produced upon the one hand and free nitrogen on the other. It is my opinion, therefore, that we are justified in accepting the following hypothesis:

Those processes of the living organism which are concerned in the expenditure of energy are so manifold that we are unjustified in accepting any preconceived limitation with regard to the processes which characterize them. There is only one condition which must inevitably be met with under all conditions, namely, *that in all chemical processes taken as a whole, the energy must diminish in order that the organism may profit by the energy liberated in the form of heat and of work done.*

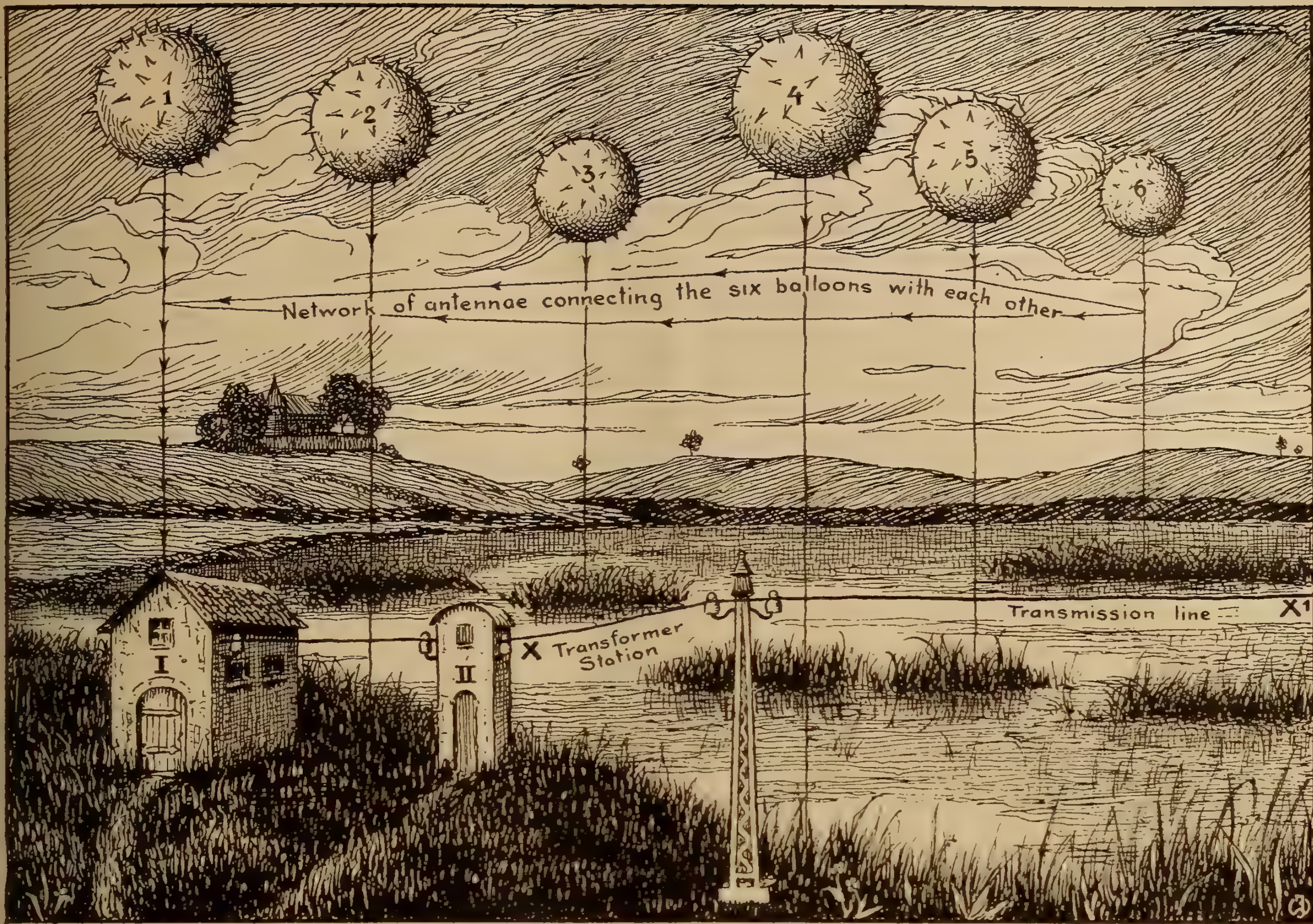
On the other hand, the coöperation of oxygen is not universally demanded by the living organism, just as economically we are by no means obliged to produce chemical energy by combustion. To build a gas motor which would burn hydrogen and chlorine would offer no insuperable difficulties to our engineers, but the thing would be absurd since the chemical energy of oxygen is everywhere available for nothing. (In connection with a lecture given upon the same subject before the *Medizin-Naturwissen.* Society at Münster i. W. Privy Counsellor Kassner called atention to the fact that gas motors of the kind just mentioned are actually in use at the present time, being employed, however, not to yield energy but to produce hydro-chloric acid).

In conclusion, we may remark, however, that the higher animals have learned to make use of the readily available chemical energy of the oxygen which is found everywhere upon our earth. And for this reason alone they are able to obtain a greater yield of work done and of heat than will be possible for them to obtain from a life without oxygen.

DO MIGRATORY BIRDS MAKE PREPARATION FOR THEIR FLIGHT?

A GERMAN professor, Dr. Thienemann, has recently raised the interesting question as to whether birds which change their place of abode in spring and fall prepare themselves previously for long journeys. Such a preparation might conceivably consist of two kinds. It might, on the one hand, include the swallowing of a definite amount of food and, on the other hand, it might consist of some modification in the character of the plumage. In other words do the birds fly with full crops from which to obtain the necessary energy for their muscular effort, or do they, on the other hand, fly with empty crop and stomach in order to lessen their weight? Furthermore, is there any difference in plumage observable just before the start?

In order to solve the first question the learned professor first experimented with caged birds in order to see how much time they required after the taking of food for the crop and stomach to become entirely empty. He found that after feeding plentifully, in the majority of cases no trace of food was left at the end of four hours, in a smaller number eight hours was required. He then examined birds captured in the act of migration. In these he found that out of 183 individuals 18 per cent had the crop and stomach full, 40 per cent had it empty and 42 per cent had it moderately filled. The majority, therefore, appeared to endeavor not to overload the stomach. The migratory instinct prevails in general over the hunger instinct. As to the second question, whether migratory birds exhibit any special care as to keeping their plumage in good condition, he believes that the birds will not refrain from migrating because of injury to the plumage or disorder in it. His observations seem to prove that the dominant instinct in migrating birds is the attempt to proceed. The stimulus which causes them to seek food is practically excluded during the time of the strongest migratory impulse, so that at times the birds appear almost entirely indifferent even to their favorite delicacies; thus the falcon migrates close beside the dove without injury to the latter.



Courtesy of "Uber Land und Meer"

PLAUSON'S PROPOSED BALLOON PLANT FOR COLLECTING AND UTILIZING ATMOSPHERIC ELECTRICITY

The electricity is periodically discharged, producing a high frequency current which flows from the collecting station I through the transformer X to the transmission line.

Capturing Electricity from the Air

Recent Studies Regarding Atmospheric Electricity and Its Possible Utilization

By T. A. Marchmay

OLD KING COAL has served mankind well but at the present hour his services are coming uncommonly high. Small wonder then that our inventors and men of science are becoming increasingly keen in their endeavors to find some source of energy which may replace, at some future day, if not in the immediate present, those stores of fossil sunlight, which within but little more than a century have revolutionized human activities and made modern actualities of Arabian Nights dreams.

One of the newest propositions of this sort, which is attracting widespread interest on the continent of Europe, where the pinch of fuel shortage is even more keenly felt than in our own richer country, is the suggestion to make use of what is believed to be the inexhaustible storehouse of static electricity contained in the upper reaches of our atmosphere. In normal weather the terrestrial atmosphere constitutes a practically uniform electric field in which the surfaces of equal potential are parallel to the earth and the lines of force are vertical. The degree of the potential increases with comparative regularity—except during periods of violent atmospheric disturbance—in proportion to the distance above the level of the ground. This difference of potential varies also according to the season of the year, being estimated at 100 volts per meter during the summer, on an average, and 300 volts during the winter. A Hamburg scientist named Plauson, who has been studying this subject for a number of years, has proposed an ingenious scheme by means of which this energy of the upper air may be captured and set to work. He has already demonstrated, in fact, that at altitudes exceeding 300 meters it is possible to capture an average of 200 horse-power per square meter; his latest experiments, indeed, have yielded as much as 400 to 500 horse-power.

He proposes to make use of a system of huge balloons having a metallic surface and connected with each other by an aerial network of conducting wires. These balloons act as collecting antennae and, that they may the better fulfil this function, they bristle with a series of points as shown in the accompanying illustration, so that they somewhat comically resemble those queer puffer fish which can inflate themselves like rubber balloons, and which likewise bristle with sharp points. Further to increase their power of capturing energy he proposes to impart conducting power to the air by ionization, and he proposes to secure this by means of radio-active salts such as radium, polonium, etc., placed at the extremities of the antennae. Each system of balloons is connected with the earth by means of non-conductors, and the vast supplies of energy thus collected in the upper strata of the air are discharged at brief intervals so as to produce a high frequency current.

This current can be utilized immediately in the preparation

of nitric acid and ozone from the air; hence if it proves practical mankind's other fear of exhausted fertility of the soil will be set at rest. By making use of suitable transformers the aforesaid current can also be employed in electro-chemistry and electro-metallurgy. A well-known French writer, M. Matignon, writing upon this subject in *Chimie Industrie* (Paris) for April, 1920, states that it is possible to produce 5 tons of carbide in 24 hours by means of the power thus captured upon a surface of 6 sq. km. Other interesting figures given by M. Matignon are found in his estimate that assuming an attainable power of 100 hp. per kilometer, the total surface of France would yield 100 million horse-power. A German writer, Fredrich Otto, writing in *Ueber Land und Meer* (Berlin) for October 31, 1920, estimates similarly that an area equal to the surface of Germany would yield 720 million hp. per day.

It would obviously be impossible, however, to devote the entire area of the country to the anchoring of flocks of huge balloons. Herr Plauson proposes to employ as locations for collecting stations such barren localities as seas and lakes, heaths, moors, deserts, steppes, mountainous areas, etc. He estimates that about one-third of the surface of Germany could thus be employed for the collecting of atmospheric electricity without interfering in the slightest degree with agricultural interests.

But what would be the expense if this grandiose enterprise were to be carried out upon the scale which its inventor enthusiastically hopes for. Herr Plauson admits that the initial cost would undoubtedly be very great, and yet he does not hesitate to assert that this aerial electrical current would be in the long run, and all things considered, considerably cheaper than that obtained from coal. He expresses the hope that the enterprise may be taken up by the government, the first steps, of course, to consist in the erection and establishing of suitable experiment stations. Such a station is shown in the picture which accompanies the text, and which was drawn by W. Jacobs.

It must be admitted that there are certain hard-headed men of affairs who fail to share the inventor's enthusiasm concerning this novel idea, but as Herr Otto justly points out incredulity has been the common fate which has attended novel ideas throughout the course of human history. Even in the early part of the present century many wiseacres considered Count Zeppelin's plans for huge dirigibles merely a colossal joke. Galvani, whose name is enshrined among the potent terms of electricity, wrote sadly in 1792, "I am attacked by two sets of men—by the wise men and by the fools." Philippe Lebon, who discovered the process of illumination by gas, was considered a perfect fool for believing that any light could burn without a wick. The Royal Medical College of Bavaria solemnly declared that steam engines and railroads constituted a crime against the public health. But it is needless to cite further examples of the obstinate conservatism of the human mind with regard to new ideas. Let us turn rather, for further light upon the potentialities of this vast project, to a consideration of the recent researches by other investigators in the fascinating field of the nature and origin of atmospheric electricity.

NATURE AND ORIGIN OF ATMOSPHERIC ELECTRICITY

Many men in many lands have followed the clue given by Franklin in 1752, with regard to the character of the mysterious and terrifying phenomenon of lightning, whose power to impress the imagination of man is borne witness to, alike in the folk lore of the savage and the loftiest literature of civilized races. Among these we may mention among the moderns Becquerel, Lord Kelvin, Peltier, Pellat, Saussure, and more recently, since the theories of ionization and of radioactivity have given a new slant to the subject, Eve, Simpson, Wilson, Birkeland, Ide, and Swann. The last named authority has been studying this subject for more than fifteen years, with all the advantage of the most admirable equipment. He has conducted his studies, both by land and by sea, in the latter case upon the boats *Galileo* and *Carnegie*, belonging to the Carnegie Institution.

In giving an account of Mr. Swann's remarkable observations in this domain, for information concerning which we are indebted to an article recently published by the *Journal of the Franklin Institute*, it is advisable, perhaps, though at the risk of some repetition, to give a brief résumé of the knowledge possessed on the subject.

The ground is not an electrically neutral body. Its surface may be considered to be covered with a layer of negative electricity and this gives birth in the atmosphere to an electrical field of considerable importance. As we have said in the earlier part of this article the difference of potential increases with the altitude; this increase is at the rate of about 150 volts per meter. This is known as the *gradient of the potential*, and is the subject of regular measurements in all observatories.

Variations of potential in the atmosphere.—Save in exceptional cases the gradient of the potential always takes the direction which results from the existence of a negative charge upon the ground. But this is not an invariable quantity; it undergoes both daily and annual variations, and is always higher in winter than in summer. As stated above the gradient decreases in proportion to the altitude. Observations have been made by means of sounding balloons up to a height of 9 km. at which level the gradient is only 2 volts per meter instead of 150, as upon the ground.

The existence of the gradient and its gradual diminution up to a height of 10 km., may be explained by assuming that this atmospheric stratum, 10 km. in thickness, contains a positive charge, which is exactly equal to the negative charge spread over the surface of the earth. Experiment has shown the existence of this positive charge, in fact.

If the atmosphere formed a perfect insulator the system constituted by a negative electric charge upon the surface of the ground and a positive charge in the surrounding atmosphere, might continue indefinitely. But this is not the case. While it is true that the electrical conductivity of the air is extremely feeble, it would, nevertheless, be sufficient to occasion in less than 10 minutes a discharge of 90 per cent of the electric charge of the ground, were it not reconstituted in some manner. It is the method by which this charge is constantly reconstituted, which has long proved a puzzle to students of electric phenomena.

The conductivity of the atmosphere.—This conductivity, compared to that of a metallic substance, like copper for example, is extraordinarily weak. Mr. Swann calculates that a column of air 1 centimeter in length offers to the passage of the current the same resistance as a copper cable of the same section, and of a length of 15 billions of millions of kilometers, that is to say, 8 times as long as the distance from the earth to Arcturus and back.

But no matter how feeble it may be the conductivity of the air is by no means nil, and modern theories of electricity are quite capable of explaining the mechanism thereof. According to these theories matter is composed mainly, if not exclusively, of positive and negative electrical particles, the latter, the electrons, carry the same charge and are the same as to dimensions and as to mass. Certain agents are capable of separating an electron from the molecule, which thereupon appears to be charged with positive electricity and constitutes the positive ion. The electron is capable of traveling a certain distance in freedom, but sooner or later attaches itself to a neutral molecule or group of molecules to form a negative ion.

It is these ions which render the air a conductor. Under the influence of an electrical field, the positive and negative ions move in opposite directions, some toward the negatively charged body and the others toward the positively charged body and become discharged. But let us suppose that some permanent source of ions exists in the atmosphere. The number of ions contained per cubic meter of air would con-

stantly increase, unless the negative and positive corpuscles tended to recombine because of their mutual attraction; the more numerous they are the more rapid this combination. We must assume, therefore, that an equilibrium is established between the number of ions produced and the number which are recombined: thus, it is supposed that six pairs of ions are produced in the atmosphere per second per cubic meter. When the number of pairs of ions per cubic meter reaches 2,400 it is found that six pairs of ions recombine in one second; at this moment equilibrium is attained and the number of ions can no longer increase.

The origin of atmospheric ions. Swann attributes the continuous production of ions in the atmosphere to two causes:

1. *Radio-active emanations* in the air;
2. The so-called *"Penetrating radiation."*

All of these radiations possess the power of ionizing either directly or indirectly any gas through which they may pass; the *alpha* particles being especially efficient so that they expend all their available energy in the process and come to rest after passing through only a few centimeters of air. The *beta* particles are much less efficient and may travel several meters before coming to rest. The *gamma* rays are still more penetrating and less efficient as ionizers, so that after passing through 100 meters of air they still retain 36 per cent of their initial value. Mr. Swann thus elaborates these ideas in an article presented by him originally at a joint meeting of the electrical section and the Philadelphia section of the American Institute of Electrical Engineers, held November 1, 1917. At the time this lecture was given Mr. Swann, who is now professor of physics at the University of Minnesota, was chief of the Physical Division in the Department of Terrestrial Magnetism in the Carnegie Institution at Washington. The following excerpts are taken from the paper as published in the *Journal of the Franklin Institute*, for November, 1919.

Now the soil contains radium and other substances of this nature, and these give rise to active gaseous emanations which diffuse out into the atmosphere. During the disintegration of these emanations in the atmosphere, α, β and γ rays are emitted with the result that the air becomes ionized and is rendered conducting. The amount of radium emantion in the atmosphere varies very much from time to time. It is, however, always extremely small. In a shell of the atmosphere extending over the whole of the earth's surface and comprised between that surface and an altitude of one kilometer, we shall find only about 250 grammes of radium emanation. Or, expressing this magnitude in another form, we may say that each cubic centimeter of the atmosphere contains on the average only between one and two molecules of radium emanation, as compared with the thirty million million million molecules of air which it holds. Nevertheless, by adding up the ionization produced by the α, β and γ rays from the emanation and its products we are able to account for the production of 1.7 ions per second in each cubic centimeter of the atmosphere. In addition to radium emanation, another radio-active gas, thorium emanation, is also found in the atmosphere and contributes to the ionization. Again, a certain amount of atmospheric ionization is attributable to the radio-active materials in the soil. Here we are only concerned with the γ ray ionization, since α and β rays are so readily absorbed that they never succeed in getting out of the soil. The soil contains, on an average, about 4×10^{-12} gramme of radium per cc., and, by calculating the amount of γ radiation which can be accounted for, after allowing for the absorption of the rays coming from different depths in the soil, we find enough to provide for the production of 0.80 ions per cc. per second. In a similar way, the thorium in the soil is found to be capable of accounting for a rate of production of 0.80 ion per cc. per second.

These results on the amount of ionization which the radio-active material is capable of accounting for are summarized in a table prepared by A. S. Eve; and it appears that, altogether, a rate of production of 4.35 ions per cc. per second can be accounted for in this way. From a knowledge of the rate at which ions recombine we can calculate the number to which they would build up in the atmosphere on account of a rate of production of 4.35 ions per cc. per second, and the result comes out to 1,320 ions of each sign per cc.

Measurements of the numbers of ions per cc. in the atmosphere are attended with considerable difficulty, for all sorts of different types are present. In particular, there is a class of ion which is very sluggish in its motion, and which is probably nothing more than an ordinary ion which has attached itself to a dust particle. On account of their sluggishness, these ions contribute very little to the conductivity, but they nevertheless influence the requirements in the matter of the rate of production of ions; for they contribute to the rate at which the ions recombine. It has been customary to measure the numbers of ions per cc. by a method which takes account of the most mobile ions only, and it appears that about 800 pairs of these exist per cc. Thus, quite apart from the direct evidence of the existence of the sluggish ions, we may conclude that ions of this type must be present, since the radio-active material in the air and soil is alone capable of accounting for 1,320 ions per cc.

The uncertainty of our knowledge of the true average values for the total numbers of ions of all kinds, and of the appropriate rates of recombination, prevents us from doing more than to say that, as far as measurements on land are concerned, the radio-active material in the air and earth is sufficient to account for the whole of the ionization produced. A difficulty presents itself, however, when we consider the results of observations made over the sea. Those who have made observations over the ocean have found very little radio-active material. Some of the most recent observations have been made on the yacht *Carnegie*, owned by the Carnegie Institution of Washington; and, as a result of observations extending over about 30,000 miles in the Pacific and Sub-Antarctic Oceans, an average radio-active content was found, for the atmosphere, amounting to only 2.6 per cent of that found on land, and the radio-active content of the sea water collected in regions remote from land was immeasurably small. Nevertheless, the number of the more mobile ions found per cc. over the ocean is as great or greater than that found over land, as shown in a table which represents a comparison of the results of the *Carnegie's* fourth cruise with those obtained by other observers at sea, and with land values. The number of ions is much larger than can be accounted for by the small quantity of radio-active material in the ocean air.

What, then, is the agency responsible for the ionization over the ocean? It appears to be the so-called "penetrating radiation." If a hermetically sealed vessel is freed from radio-active air, we nevertheless find that ions are produced in it at a fairly constant rate of about 10 ions per cc. per second over the land. An appreciable proportion of this ionization is due to the α ray radiation which comes from the soil and passes through the walls of the vessel. That the whole of it is not due to this cause is, howsver, borne out by several circumstances. In the first place, ionization in closed vessels is found to take place over the ocean, where there is practically no radio-active material, and it there amounts to about 4 ions per cc. per second in a copper or a zinc vessel. Scondly, if, in experiments on land, the apparatus is surrounded by a wall of water of sufficient thickness to shield off practically completely the α ray radiation from the earth, there still remains a rate of production of about 4 ions per cc. per second. But *strongest evidence of the reality of the penetrating radiation* is to be found in the results obtained in balloon ascents by W. Kolhörster. It appears that, with increase of the altitude, the ionization within a closed vessel at first diminishes up to an altitude of 700 meters. This we should expect as a result of the absorption of the earth's γ ray radiation by the atmosphere. Above this altitude an astonishing thing happens, however. The ionization commences to in-

crease, and goes on increasing with greater and greater rapidity until, at an altitude of 9,000 meters, the intensity of ionization is in excess of that at the earth's surface by about 80 ions per cc. per second. An increase of 20 ions per cc. per second takes place in the last kilometer, and the rapidity of the increase at these higher altitudes is such as to suggest that very large values of the ionization would be obtained at altitudes not very much greater.

It thus appears that there is some source of ionization other than the radio-active materials in the soil and lower atmosphere; and this agency, whatever its origin, appears to be the sole source of ionization over the ocean. The rate of production of ions must certainly be greater over the land than over the ocean by the amount attributable to the radio-active materials on land. It is probable, however, that over the land, where dust nuclei are more plentiful than over the ocean, a much larger proportion of the ions produced join the slowly moving class than in the case with the ions produced over the ocean; and it is to this cause that we must attribute the fact that the ionic density for the more mobile ions is no greater over the land than over the sea.

To return to the remarkable increase with altitude shown by the ionization within closed vessels. Such a variation at once suggests a radiation coming from some source external to our globe, or from some active agency in the upper regions of the atmosphere, the decrease in intensity encountered as we *descend* into the atmosphere being accounted for by absorption. The rapidity of the absorption can be calculated from the observations on the variation of intensity with altitude; and it appears that the observations require us to assume for the radiation a penetrating power ten times that of the most penetrating γ rays known in radio-active substances. We must not be too skeptical as to the possibility of the existence of so penetrating a radiation, for light itself is extremely penetrating as regards air, since we can see the stars through the whole thickness of our atmosphere. The "penetrating radiation" is not light, however, for it can pass through the walls of a metal vessel. Its true origin remains one of the most interesting speculations of atmospheric electricity. Linke has suggested a layer of strongly radio-active cosmical dust in the atmosphere at an altitude of 20 kilometers. For my own part, it seems more natural to seek an explanation from another standpoint.

It is generally supposed that the Aurora is due to light generated by the impact, with our atmosphere, of negative electrons shot from the sun. The stream of electrons is not confined to the sunlit side of the earth, since the paths of the electrons are bent in passing through the earth's magnetic field, and some enter our atmosphere on the side remote from the sun. Now it is a well-established fact that when electrons strike molecules of matter X rays are produced. The greater the velocity of the electrons, the higher the penetrating power of the X rays produced. γ rays themselves are nothing more than a particularly penetrating type of X rays. Modern developments in our knowledge of X rays and γ rays have taught us how to calculate the velocity which an electron must have in order to produce γ roys of any given degree of penetration. Now, from considerations of the theory of the Aurora, into which time will not permit me to enter, Birkeland has shown that it is necessary to assume that the electrons which are responsible for this phenomenon have an energy enormously greater than that of even the swiftest β rays with which we are familiar in the laboratory; and, if we invoke the assistance of these high-speed electrons necessitated by the theory of the Aurora, we find that their speed is sufficiently great to account for the production of a γ ray radiation of a degree of penetration fully as great as that of the "penetrating radiation." The electrons themselves are not the "penetrating radiation" for, in spite of their great energy, they could not travel right through our atmosphere. By conversion of their energy into the γ rays, however, a radiation of much greater penetrating power is created.

The cause of thunderstorms.—In any discussion of atmospherical electricity, naturally, the origin of thunderstorms must take an important place. The most successful theory to afford a full explanation of these phenomena, is that suggested by G. C. Simpson, which has been further developed on the meteorological side by W. J. Humphreys.

The theory is founded on the experimental fact that if water is broken into drops by allowing it to fall upon a rising column of air, the drops are found to be positively charged while the air receives a negative charge. Now experiment has shown that it is impossible for drops of water to fall through air which is rising with a velocity greater than 8 meters per second. If the drops are very small they will be blown up by a rising column of air, and it is in general necessary for a drop to have a certain minimum mass before it can fall through a column of air rising with specified velocity. If the velocity is as high as 8 meters per second, however, the size which the drop would have to attain in order to fall through the column would be so great that the drop would be broken up by the air stream, even if it succeeded in attaining the necessary size temporarily. The smaller drops formed as a result of the disintegration would, of course, be carried upward by the air stream.

Now it is a matter of common experience that thunderstorms are always preceded by high winds, and a close examination of the phenomena shows that, in the storms which give rise to electrical discharges, columns of air are to be found rising with very considerable velocity. We may liken one of these columns of air to an hour-glass, or dice box. At the bottom the column is wide. At the narrowest part of the column the air attains its maximum velocity, while at the top it fans out and the velocity again becomes small. Now in the period prior to a thunderstorm, the air is very humid. As this air rises and becomes cooled in the process, it eventually reaches a temperature at which drops of water begin to condense out. At first, these drops are carried upward with the stream; but, as they grow, they eventually reach a size at which they start to fall. Suppose that when this occurs, the drops are some distance above the narrowest part of the air column. Then, as they fall and continue to grow in size they eventually reach a place where the velocity is sufficiently great to break them up. The smaller drops become positively charged in the process and the air receives a negative charge. The small drops now start their ascent again, although, of course, with velocity less than that of the air. As they rise they grow, and eventually the whole process is repeated again. The cycle may be gone through several times, the drops becoming charged more and more each time. The free negative ions which ascend with the rising air eventually coalesce with the finer water drops to be found at the top of the cloud, so that we eventually attain a state of affairs in which the water at the top of the cloud is highly charged negatively, while that in the middle of the cloud is highly charged positively. When the accumulations of charges are sufficient to result in a field which will break down the insulation of the air at some point a lightning flash follows. It thus appears that the high winds which are associated with the thunderstorm are in no sense a result of the electrical manifestations; the electrical phenomena are themselves secondary features resulting from the air motion.

During the turbulence associated with the storm, some of the large drops of positively charged rain which have gone through the cycle of breaking and reformation several times get carried to places where the velocity of the upward current is not sufficient to break them up, and they fall to earth. In this way we find the explanation of the experimental fact that the heavy rain of the thunderstorm is found to be positively charged. On the other hand, the rain which accumulates at the top of the cloud, and which is negatively charged is of the finer type, and may be expected to fall to earth only in the lulls between the periods of most violent activity, or at places somewhat remote from the storm center. Here, again, experiment sup-

ports the conclusions in showing that the finer rain which falls during the quiet periods of the storm is negatively charged.

HOW THE EARTH'S CHARGE IS MAINTAINED

Since the earth is constantly losing negative electricity because of the action of the potential-gradient operating in the conducting atmosphere, it is of importance to inquire how its charge is maintained. The current from a square centimeter of the earth's surface is only about 2×10^{-16} amperes. The current from the whole earth is only about 1,000 amperes, or about as much as is taken by 3,000 incandescent lamps. It is nevertheless sufficient to insure that 90 per cent of the earth's charge would disappear in ten minutes if there were no means of replenishing the loss. How then is the loss replenished?

One of the earliest suggestions was made by G. C. Simpson, who supposed tentatively, that the sun emitted positive and negative corpuscles of a very high penetrating power. He further supposed that the penetrating power of the negative corpuscles was greater than that of the positive corpuscles, and sufficient to enable them to reach the earth's surface, while the positive corpuscles were caught by the atmosphere. In this way the attempt was made to account for the negative charge of the earth and the positive charge of the atmosphere.

As a matter of fact, it is unnecessary to go to any special pains to account for the maintenance of the negative charge on the surface of the earth. For it is an experimental fact that the atmospheric conductivity increases with altitude until its value at an altitude of nine kilometers is about thirty times the value of the earth's surface. It follows from this that if the potential-gradient were the same at an altitude of nine kilometers as it is at the earth's surface, more negative electricity would be driven outward through a sphere at the altitude of nine kilometers and concentric with the earth than would be driven out of the earth's surface into the atmosphere. The shell of air below the altitude in question would consequently acquire a positive charge, so that the potential-gradient at the altitude of nine kilometers would become less than that at the earth's surface. The process would continue until the diminution of potential-gradient with altitude was just sufficient to compensate for the increase of conductivity with altitude so as to leave the conduction current-density independent of altitude.

The chief objection to Simpson's tentative theory, however, is one which he himself supports in a recent publication (*Some Problems of Atmospheric Electricity. Monthly Weather Review*, vol. xliv. pp. 115-122, 1916), viz., that it postulates a degree of penetration for the corpuscles so enormously great compared with any corpuscular penetration we have become acquainted with in the laboratory since the suggestion was put forward, that one hesitates to make this hypothesis without further evidence.

Other hypotheses have been formulated by various scientists, particularly the German, Elster and Geitel, and the English physicist C. T. R. Wilson. To go into these various theories would take us too far afield but that of Wilson is worth mention, because it is connected with his important discovery in regard to the part played by ions in the condensation of water vapor. His hypothesis is that the ions act as nuclei which promote the condensation of water vapor, and he observed that the vapor is condensed more readily upon the negative than on the positive ions. He, therefore, argued that rain should be on the average negatively charged. Swann, however, points out that unfortunately 75 per cent of the charge brought down by rain is of the positive sign; he, also, raises several other objections to this theory which he considers fatal.

PENETRATING RADIATION

Swann himself finds the explanation of the electric charge of the ground in *penetrating radiation*. The study of the γ rays has shown that the ionization occasioned by them consists of an emission of electrons projected in the direction of the incidental γ rays and which are themselves endowed with a power of penetration, whose degree varies in proportion to the penetrating power of the radiation to which they owe their origin. Hence, electrons produced by the ionization of an extremely penetrating radiation may travel a considerable distance before coming to rest.

Thus the successive strata of the atmosphere are traversed by electrons set free from the upper layers; these corpuscles in their turn come in violent contact with molecules of matter, thereby giving rise to a penetrating radiation which occasions the emission of new electrons directed toward the ground—and thus we come nearer and nearer to the ground, which finally receives the electrons sent forth in the layers of air in its immediate proximity. At every point of the atmosphere, therefore, we must suppose that there is a current of electrons passing from the top to the bottom and animated with great velocity by the penetrating radiation; and, likewise, that there is a conduction current moving in the opposite direction carrying the negative electricity of the ground to the atmosphere, so as to establish a state of equilibrium.

Mr. Swann's article also contains a section upon atmospheric-electric measurements, including that of the penetrating radiation, which is somewhat too technical to be included in this brief account of his valuable researches.

ELECTRICAL CONCENTRATOR IN SULPHURIC ACID MANUFACTURE

An electrical concentrator has been installed by the Chemical Construction Company at Mount Holly, N. C., and has been operated intermittently for several months with good results. During 1918 a one-ton capacity unit was installed at a chemical plant at St. Albans, W. Va.

This concentrator is designed for small capacities where electrical current is available and comparatively cheap. It consists of a small bath space built of acid-proof masonry in which are placed two electrodes of acid-proof iron spaced about 2 or 3 feet apart, the electrodes being adjustable. The bath of acid is also so arranged that the level may be lowered or raised. There is a dam of acid-proof masonry between the electrodes. The weak acid is fed in at one end of the furnace near the electrode and flows over the dam to an outlet at the other end. The electric current between the electrodes passes through the thin layer of acid flowing over the dam and heats this thin layer to the point where the water is evaporated at a rapid rate.—A. E. Wells and D. E. Fogg, Manufacture of Sulphuric Acid in the United States; 1920 Bureau of Mines Bulletin, No. 184.

TRANSMISSION OF ELECTRICITY FROM NORWAY TO DENMARK AND SWEDEN

The possibility and practicability of harnessing the waterfalls in southern Norway and distributing 3-phase current of 50 periods at a pressure of 220 kilovolts to southern Sweden by aerial lines and to Jutland through a 45-mile long cable across Kattegat from Gothenburg to the Skaw, is discussed by Eivind Hanssen in *Teknisk Ukeblad*, June 11, 1920.

Sealand and Copenhagen could be supplied by extending the overhead line south across the Sound by a cable three miles long near Elsinore. The total length of the aerial line will be not less than 500 miles. The author admits that the highest voltage at present in use is 155 kv., but is of the opinion that an increase to 220 kv. would not cause insurmountable difficulties. Two American lines, which work at a pressure of 155 kv., have been found quite satisfactory, and it has recently been proposed to transmit 1.5 million kw. at a pressure of 220 kv. in one of them. The Norwegian-Danish line would, as a first installment, carry 155,000 kw., there being no difficulty in selling this output in Denmark.—Abstracted by the *Technical Review*.

The Photo-Ratiograph*

A New Instrument for the Study of Vibrations

By A. C. Banfield

THE question of the interference of vibrations is one which has long commanded the close interest of scientific men, whether they are those met with in the study of light, electricity, heat or sound. In these cases the question of vibrational interference is of the greatest economic importance, affecting matters so remote from each other as the tone of a piano and transmission of electrical energy from one locality to another.

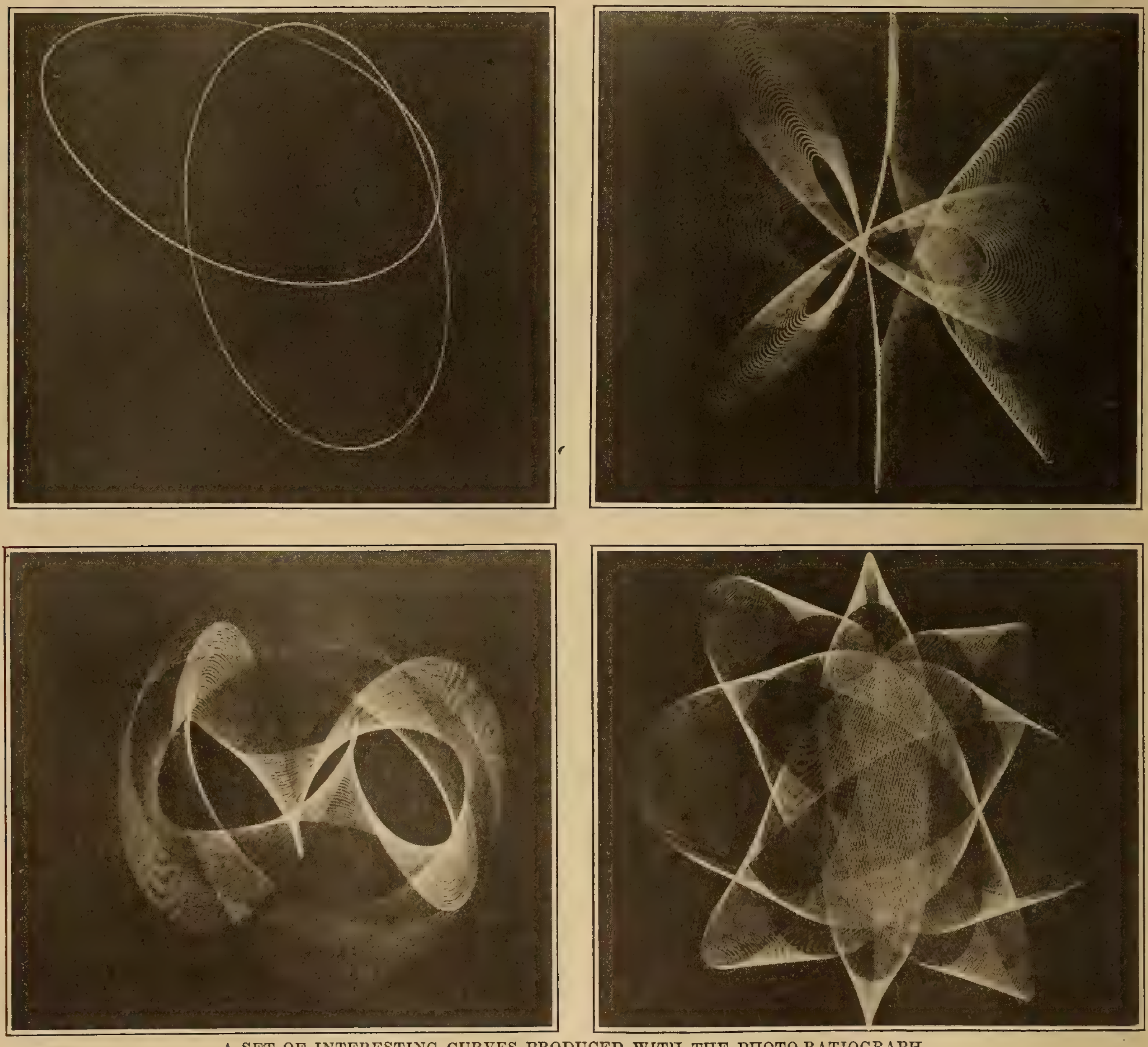
Quite another class of vibrational interference has long commanded a large amount of interest from two sets of people: the scientific dilettante, for the exquisite beauty of the resultant curves; and the mathematician, for the fundamental laws on which these beautiful curves are based. These curves are generally known as "harmonograph" drawings.

The harmonograph, generally speaking, is somewhat tolerantly regarded in physical circles as a scientific toy, though the beauty of the result never fails to excite admiration, grudging though it may be. The cause of this attitude probably lies in the fact that science always deals with exact premises, and in this the usual pendulum-controlled harmonograph fails lamentably. It is impossible to state definitely, for example, exactly the path which the pendulums are describing—it may be anything from a straight line to a circle, but it is usually more or less elliptic.

An essential to any apparatus of this class—that is, if it is to possess any scientific value—is that it should be capable of tracing exactly the curves which are compounded, and also that it should record, if necessary, cases in which one of the vibrations is increasing in amplitude while the other decreases. Needless to say, the pendulum cannot achieve either of these *desiderata*. To place the matter on a more satisfactory basis, the writer designed and constructed the apparatus which is illustrated here.

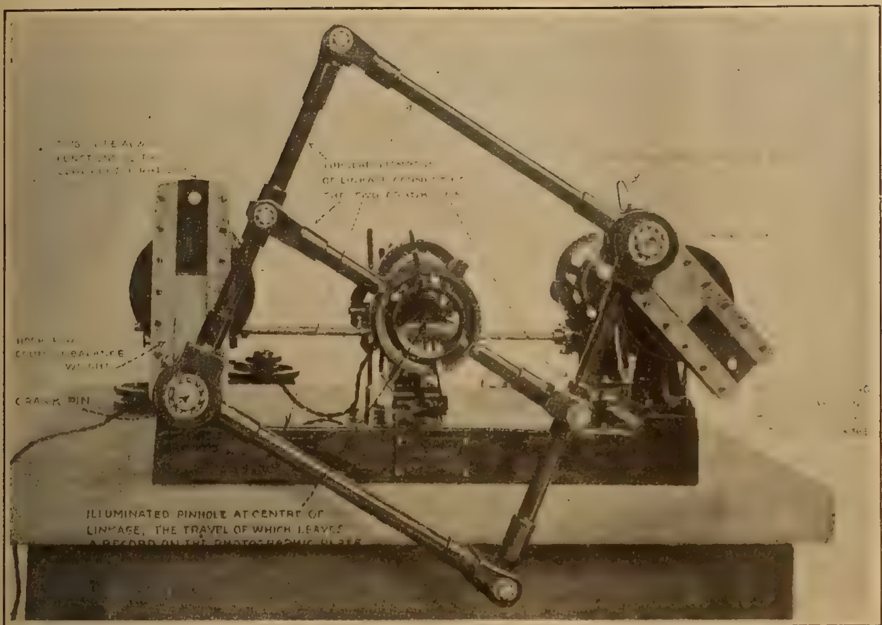
It is difficult to explain in non-technical language exactly what is meant by the composition of the two vibrations. If

*Courtesy of *London Illustrated News*.



A SET OF INTERESTING CURVES PRODUCED WITH THE PHOTO-RATIOGRAPH
(Note the basic elements of the curves in the upper left-hand engraving)

the reader will turn to the basic elements of the curves shown in the upper left-hand illustration of the curves, he can get an idea if he will imagine an impalpable sort of locomotive progressing around each of the two curves. One of the engines can complete three circuits while the other makes, say, five journeys around the other curve. This gives us our first factor, that of ratio, in the above example 3—5, though naturally it may be any other pair of numbers if necessary. Again, the engines are not limited in the direction in which they may traverse the curves: they may proceed in the same or opposite directions—giving us the second factor, that of rotation, which accordingly is termed either concurrent or opposed.



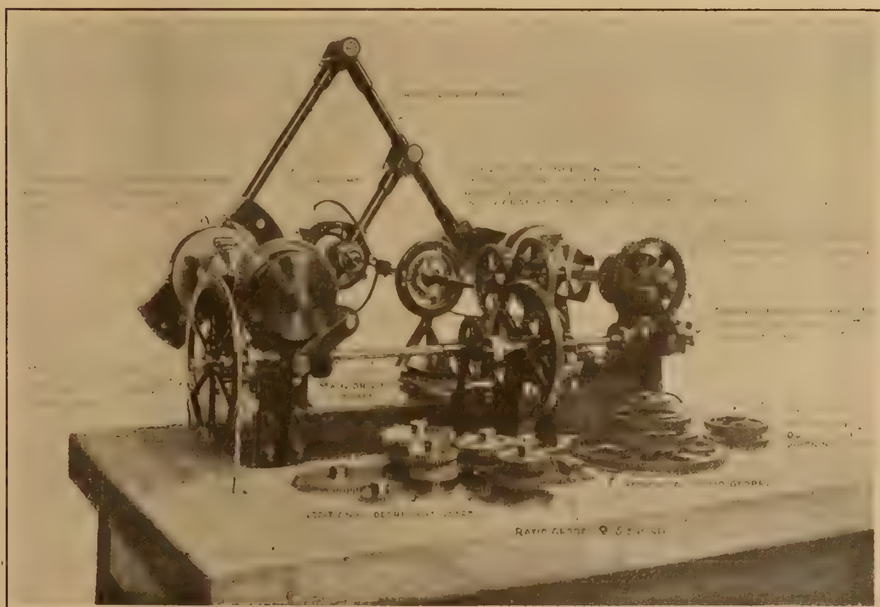
FRONT VIEW OF THE PHOTO-RATIOGRAPH

Several other factors enter into the determination of these curves, but the only other one necessary to notice here is that of decrement (with its converse of increment). Our mythical engines will help us also to understand this. If their supply of steam were unlimited, they could traverse their curves *ad infinitum* at their allotted ratio. However, their supply of steam immediately commences to fail them, and the only way they can keep the ratio constant is to run around a similar but shorter path.

One must not, however, push the somewhat weak analogy of the two engines too far. To get at the real state of affairs, we have to replace them by the force which they represent, a force which is persistent and periodic. It is evident that in such a case the two forces will at times assist each other, and, conversely, will also periodically annul each other, with the result that, instead of our two simple basic elements, we get a more or less elaborate design which represents the compounded path of the two vibrations.

Turning now to the instrument shown in two of the accompanying illustrations, it will be noticed that, instead of depending on the action of pendulums, a mechanical linkage is used to compound the two vibrations. This linkage is of such a nature that the central point, which is represented by a very small brightly illuminated pin-hole, always exactly bisects the distance separating the two crank-pins, whatever their position may be around the circle. The linkage, in short, is a kind of inverted pantagraph. The result of this arrangement is that, assuming one of the cranks is still, on turning the other the pinhole at the center describes a circle half the diameter of that described by the moving crank. By this arrangement it is possible to compound any two circular vibrations.

Compositions of circular vibrations, however, are not the most interesting. By attaching a lamp provided with a suitable pin-hole to various points of the linkage other than the center, an immense and never-failing source of irregular closed curves immediately becomes available. The illustrations reproduced, it will be noticed, belong to this class. In each case the natural vibrations are shown and it seems impossible that when they are caused to interfere with each other the result should be so elaborate. A question is frequently asked of the writer: "Is it possible to reproduce one of these figures?" It is quite easy, and has been done many times, provided that the factors are known, or the basic curves available. It will be noticed that photography has been adopted as a recording medium. This has been done for several reasons. The usual glass pen is a nuisance on several grounds; it is difficult to keep it in order, it introduces friction at the worst possible point, and in these days, when good paper is very difficult to obtain, it is more than inclined to give a bad record. These are absent from the photographic method, which has the additional advantage that the record is an index of the velocity at which the pin-hole is travelling at any given part of the curve; on the print, naturally, the lightest portions are those where it is travelling at its slowest.


THE PHOTO-RATIOGRAPH AS VIEWED FROM THE REAR

In order to make a record, all that has to be done is to start the machine, and let the movement of the pin-hole record itself on a photographic plate, an ordinary camera being used in a darkened room.

The photo-ratiograph as here described is not as yet completely finished. So far it can only deal with strictly circular and irregular basic curves. When complete, its field of usefulness will be greatly extended, for it will be able to deal with eliptic curves and the allied fascinating problems of phase and precession in all their bearings.

Electric Phenomena in Extreme Vacuo*[1]

Can an Electric Current Exist in a Space Absolutely Devoid of Matter

By Dr. H. E. Lilienfeld

ONE of the main principles in physical science is that there are *two kinds of electricity, namely, positive and negative.* Each of these two kinds of electricity may exist quite independently of the other; equal quantities of opposite kinds mutually neutralize each other.

But this original conception of two kinds of electricity has been continually more and more modified of recent years and confined to the special condition that the *negative* electricity is divided into separate particles of like magnitude (quantitatively) and attached to a carrier of their own sort, i.e., the electron whose mass is about 1/2000 part of that of an atom of hydrogen. Positive electricity, on the contrary, is never found except attached to an atom or molecule and does not exist, therefore, except in the form of *"positive ions"*.[2]

When we think, therefore, of a portion of space absolutely free from matter—i.e., of an *absolute vacuum*—and question searchingly whether an electric current can exist in such a vacuum and if so, how,—then the answer will be in accordance with the concepts just indicated, that it is probably quite possible to have an "electric discharge" without any participation on the part of matter. It will be characterized, however, by the fact, that *positive carriers of electricity will not appear*—the entire transport of the current in this imaginary experiment (supposed to be carried out in an absolute vacuum) being attended to rather by the negative carriers—the electrons. The electrons will make their appearance at the negative electrode (cathode) K (Fig. 1) in the absolute vacuum and will leave the vacuum once more at the positive electrode (anode) A passing into the circuit.

This simple imaginary experiment suggests some very illuminating reflections. The electrons which leave the cathode move toward the anode with *finite* velocity. Consequently there elapses a finite period of time between the instant at which the electrons leave the cathode and the instant at which they reach the anode. During this period of time the electrons remain in the space which separates the two electrodes. As a result a negative discharge of this space—in colloquial language a "negative space charge"—is occasioned. In accordance with the principle that forms of electricity bearing the same sign repel each other, this existence of the negative space charge exerts a repellent effect upon the electrons which should pass into the space from the cathode and thus makes the passage of the current more difficult. This is shown by the fact that the source of the current E (Fig. 1)—i.e., a storage battery or a dynamo—which makes the discharge manifest must furnish a higher tension the stronger the current of electrons is, and, consequently, the higher the strength of the discharge current in the absolute vacuum is required to be.

As has been often pointed out the above considerations are valid only in the case that there is an *absolute vacuum* inside the glass vessel G which surrounds the electrode—in other words, that there is not a single molecule present in this space. We will now discuss the question as to what change the phenomena would undergo if a very slight trace of gas were allowed to enter the vacuum—possibly through the valve V—while a given strength of the discharge current was maintained. We must keep in mind that the presence of the very first molecule of gas to enter involved the possibility of the appearance of positive ions. That is, when electrons are moving with sufficient velocity and in great numbers in a space containing even a single molecule it becomes highly probable that the said molecule will come in contact with the electrons. When such a clash occurs new electrons are split off from the molecules—physicists term this a formation of positive ions by means of "shock ionization." The presence of

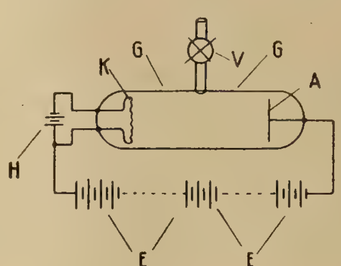


FIG. 1

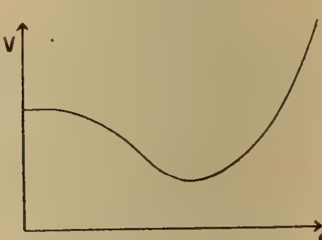


FIG. 2

such positive charges obviously has the effect of neutralizing a portion of the negative space charge. In other words, the space charge is decreased by the appearance of the first trace of gas. Through this, however, the passage of the electrons from the cathode into the vacuum is facilitated, so that the tension required for the introduction of a discharged current of the same strength is less when there is a trace of gas in the enclosed space than that in the absolute vacuum. In fact, the current increases faster in such a case with the augmenting tension than it does in the absolute vacuum.

Let us now continue our imaginary experiment a step further by letting the valve V remain slightly open so that the density of the gas inside of the container G increases very rapidly. If we consider what now will take place from the point of view of the space charge, we can but predict that the space charge will constantly decrease and that hand in hand therewith the tension required for the maintenance of a given strength of current will become constantly less.

However, the point of view of the space charge is entirely too one-sided, by reason of the fact that the passage of the current is influenced in yet another manner by the gas which continues to flow into the vessel with a constantly increasing density. The appearance of a considerable density of the gas naturally occasions a disturbance of the regular current transporting motion of the electron. For the denser the gas the smaller the chance there is that an electron can travel from the cathode K to the anode A in a straight line without coming into contact during its passage with a molecule and thus being diverted from its prescribed path. To this degree, therefore, the increase in the density of the gas increases the difficulty of the transport of the electricity.

This difficulty becomes so serious after a certain degree of density of the gas is attained that as this density increases the *facilitation of the discharge* dependent upon the decrease of the space charge is counterbalanced or even reversed.

The alteration of the tension required for the maintenance

*Translated for the *Scientific American Monthly* from *Die Umschau* (Frankfurt).

[1] Here follows a brief list of the articles pertaining to this subject already published by Dr. H. E. Lilienfeld:

"The Conduction of Electricity in Extreme Vacuo," *Annalen der Physik*, 4th Series, Volume 32, pp. 763-738, 1910; *Annl. d. Phys.* 4th Series, Volume 43, Pages 24-46, 1914; and "Concerning the Discharge of High Vacua," *Annl. d. Phys.* No. 2, Feb., 1920.

Compare also the article "High Vacuum X-Ray Tubes, *Jahrbuch der Radioaktivität und Elektonik*, Vol. XVI, No. 2, pp. 105-189, 1919. The remaining literature concerning this subject will also be found collated in these articles.

[2] So-called "negative ions" also exist. It is generally supposed that a negative ion is formed from a neutral atom or molecule by the taking up of an electron, whereas the positive ion is formed by the splitting off of an electron. According to this theory, therefore, *the magnitude of the electric charge* which is the very foundation of the formation of positive and negative carriers of electricity; in other words, the so-called "elementary charge" would be *always the same.* In a later footnote we shall refer briefly to the researches by Ehrenheft which contradict this idea.

of a given current which is consequent upon an increase in the gas-density may, therefore be expressed as follows (as indicated in the diagram shown in Fig. 2): *The tension V conditioned by the gas-density d=o of the negative space charge is diminished by the first traces of gas, reaches a minimum, and then begins to increase once more as the density of the gas increases further.*[3]

It is of the greatest interest to solve the problem as to what becomes of the energy which is given off from the accumulator battery E to our discharge space. In accordance with the law of the conservation of energy this work done by the accumulator battery E cannot be lost—where then, and in what form will it next appear? The answer is readily found if we again assume to begin with that there is an absolute vacuum. The electrons yielded by the cathode will be accelerated in the field between the electrodes and will absorb the energy in the form of *kinetic energy.* We can represent it to our minds by saying that the negatively charged electrons are attracted by the positively charged anode just as a stone dropped from the top of a tower is attracted by the earth. Just as the stone strikes the earth at its utmost velocity and thereby has its energy transformed into heat, so in the case before us the electron strikes the anode and heats it. Thus we may formulate the law:

The total[4] *energy of the process of discharge will be—given an absolute vacuum—given off at the anode in the form of heat.*

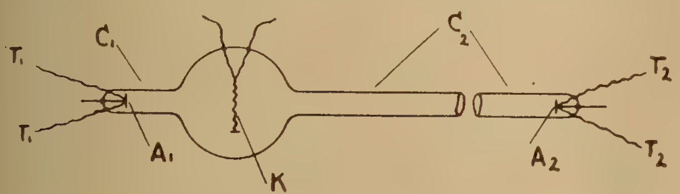


FIG. 3

If, however, we suppose gas molecules to be present in the discharge space then this law ceases to be valid. The mutual impacts which take place between electrons and the gas molecules, under these circumstances, cause a portion of the energy of the electrons to be split off on their way before the electrons reach the anode, by reason of the deviation in direction of the particles due to the shock, and this energy is given off at one side of the glass wall G, which as a consequence thereof, becomes heated. In this case we must suppose, likewise, that because of these electrons which come into contact with the glass wall, and remain hanging there, there does not ensue permanent negative charging of the glass wall—which charging, however, would indeed be hindered by further electron impacts and the durable heating consequent thereupon—by reason of the fact that the positive ions which are present are ready immediately to counteract a negative charging of the glass wall.

Let us now consider how far it is possible to realize the imaginary experiment represented in Fig. 1.

To answer this question two points must be taken into consideration; *first,* the production of a cathode K from which numerous electrons are permanently given off, and *second,* the question as to how far the experimental means at our present disposal will enable us to secure the *ideal condition of an absolute vacuum.* All the other portions of the experiment can be readily realized with the physical apparatus in daily use in our laboratory.

As a matter of fact it is quite possible for the physicist to prepare a cathode permanently giving off a large number of electrons. It was noted as far back as the creation of the first incandescent lamp by Edison that an incandescent filament of carbon (and the same thing was later found to be true of an incandescent metal wire) gives off negative electricity. This phenomenon has been explained by Richardson and his disciples by saying that the heating of the metal causes the electrons which the metal always contains, to enter into lively motion and even enables them to break away from the metal, because the increase in their energy of motion imparts to them the capacity for conquering the superficial tension, which at lower temperatures prevents their exit. In accordance with this view we need only develop the cathode K of Fig. 1 as an incandescent metal wire raised to incandescence by an extremely small accumulator battery H in order to realize the requirements of this portion of the series of experiments involved in the general imaginary experiment.

The second of the two questions, namely, *whether it is possible to realize a sufficiently high degree of vacuum,* cannot be answered in the same simple manner. We must go about it as follows: In a cubic centimeter of gas, at a pressure of one atmosphere and at 10° C. there are contained 2.77×10^{19} molecules (according to the Loschmidt calculation). This degree of density of the gas *in vacuo* it is quite possible to obtain by the best modern technical methods including the newer pumps, low temperatures, and absorption process[5], and thus we may achieve an estimated number of 10^{10} molecules to the cubic centimeter. Whether this very respectable degree of vacuum is indeed low enough to cause the theoretically deduced results indicated in the imaginary experiment of Fig. 1, to be approximated, can be decided only by means of experiments consisting of the measurement of current tensions. As a matter of fact I am able to state in this connection that *I have, myself, conducted and described experiments whose results fully correspond to the observations represented in the diagram of Fig. 2.*

Most worthy of note, however, appears to be the fact that series of experiments can be instituted in which the space-charge becomes nil and in which the law of the transference of the entire energy of discharge to the anode *ceases to be valid.* An example of such an arrangement is shown in Fig. 3. We have here a tube provided with an incandescent cathode K and the two anodes A_1 and A_2. The anodes are placed in the two cylindrical tubes C_1 and C_2 having the same inner diameter of about 20 mm. *but being very different in length.* In one experiment the length of C_1 was 80 milimeters, whereas that of C_2 was 700 mm. Under these circumstances the tension required for the maintenance of a given discharge current at the more distant anode A_2 is far greater than the tension required for the maintenance of the given current at the nearer anode A_1. It might be expected in accordance with this that given the same strength of current the anode A_2 would be considerably hotter than A_1.

Observation proves, however, that in both cases the quantity of heat given off at the anodes is practically the same within the limits of possible error.

In this case by far the greater portion of the energy of the discharge is given off at the glass wall in such a manner that even the tube C_2 of the extreme length of 700 mm. is evenly heated throughout its entire length and this to a temperature so high as 300 centigrade. Only a comparatively small fragment of the energy of discharge is shared with the anodes. In physical terms this is to be explained by saying that in the discharge system there is an irregular motion whose energy exceeds by far the energy of the regular current transporting movement.

[3]Phenomena represented in the diagram of Fig. 2 were not only observed by me for the first time, but were likewise indicated in the manner shown.

[4] Strictly speaking a small fragment of the electron energy is converted upon the contact with the anode into radiation, i. e. into X rays. This fragment, however, in the case of the tensions here concerned is less than 1/1000 part of the amount of energy and may, therefore, be ignored in the discussion.

[5] For the purpose of the production of extreme tenuity in gases it is indispensable to have at one's disposal a plant for the liquefaction of gases (a system of low temperature apparatus. Such a plant is connected with the Leipzig Physical Institute, and it is possible here to obtain the temperature of freezing hydrogen. A goal worth striving for is the continuance of high vacuum researches by means of liquid helium.

So far as the foregoing facts are concerned the most obvious conception of the matter is that the ionization of the remainder of the gas must be held responsible for the extraordinary deviations from the ideal case deduced with regard to the absolute vacuum—and this view is especially fatal by the fact that in the cylindrical paths of discharge represented in Fig. 3, there is undoubtedly an extraordinary density of rapidly moving electrons with a comparatively less dense content of gas.

This concept of ionization was accordingly stated by me in the first of my works dealing with phenomena in extreme vacuo. But later observation soon showed that this view was far from providing a satisfactory explanation for all the phenomena involved. And this is chiefly true, indeed, because all of the observable magnitudes undergo practically no alteration, even when the density of the gas varies within wide limits, provided that the variations of the gas density take place under sufficiently low degrees of pressure.[6] It seems, therefore, extremely improbable that it is the ionization of the gas residue which occasions the deviations from the theoretical consequences deduced.

If we compare the experimental results described in a portion of this article with the imaginary experiment described in the beginning and represented in Fig. 1, we are justified, therefore, in forming the following conclusions:

There is a class of discharged phenomena in extreme vacuo which have been thoroughly studied by experimental methods and which fails to agree with the consequences deduced from the theory of a negative space charge. In order to represent these phenomena in a comprehensible (mathematical) manner we are forced to assume that besides the negative carriers of the charge (i. e. electrons) *positive charges also are to be found in the most extreme vacua which it is possible to attain.*

For such a representation of *certain aspects of the phenomenon* it is a matter of entire indifference whether we conceive these positive charges as ions formed from the gas residues by means of shock ionization or in any other way—it is sufficient for this *narrower purpose* merely to recognize the production of positive charges of one sort or another. If, however, we desire to obtain a concept of the results of observation in their *fullest extent* which shall be quite unexceptionable, it is apparently not possible to content ourselves with a simple concept of an ionization of the gas residues. *One possible explanation,* which is the one which comes most readily to mind in so far as it makes immediately comprehensible the independence of the phenomena from the density of the gas, is the theory suggested by myself to the effect that positive quantities of electricity (in what is at first not a more nearly definite manner—i. e. continuously distributed, or united with discrete carriers in quanta) are produced in the discharge system when the space density of the negative electron exceeds a definite limit. As a result of this concept, therefore, there would be *positive charges quite independent of the gas residues* which would abolish the negative space charge and likewise affect the other deviation from the theory. Of course, it must be quite obvious to the reader that *this story of such positive charges*[7]*—considered from the general scientific viewpoint—involves a new basic concept of vast scope, namely, the possibility of creating a condition of dissociation within a portion of space entirely free from matter.*

In this connection I may likewise remark briefly that the phenomena which make their appearance at the anti-cathode of the X-ray tube also indicate the presence of a characteristic positive charge. But since the anti-cathode of an X-ray tube is, as a matter of fact, the anode of a high vacuum discharge, it may be regarded as evident that fundamentally these phenomena also belong to the subject here treated.

MULTIPLE TELEPHONY AND TELEGRAPHY

THE German State has been carrying out a series of experiments on the use of high-frequency currents in wires for the transmission of several simultaneous sets of telegraphic or telephonic signals. These tests related to such matters as methods of connection, modes of transmitting speech, filtering out at receivers, speech amplifiers, determination of electrical characteristics of conductors and so forth.

Since October, 1919, a line between Berlin and Hanover (300 km.) has been in operation for threefold telephonic conversations, and it is possible for any subscribers in either towns to converse together with their normal instruments. A similar installation is in use between Berlin and Frankfurt (600 km.). The high-frequency currents are generated by Telefunken oscillation valves, and may be adjusted to have wave lengths between 200 and 20,000 m. There are no technical reasons why 10 or more conversations should not be carried on over one circuit, but the installation expense of such a system would be very considerable.

Multiple telegraphy is in many ways simpler than multiple telephony, but the development has been slower owing to the fact that it was not so urgently needed. The first practical tests were carried out on a line of 600 km. length between Berlin and Frankfurt a.M. The signals are given by negative current pulses, while the positive current is used for disconnecting. The pulses are not sent directly into the line, but actuate a relay that throws the high-frequency generator on and off the line in step with the signals. At the other end of the line the high-frequency currents are amplified and admitted to the receiver. The installation has been operating on duplex work since last December, and in 8 to 9 working hours handles up to 2,000 telegrams, or 30 per cent of the total service between Berlin and Frankfurt. Recently the system has been used for sixfold telegraphy on a line carrying in addition one ordinary telephone conversation. This corresponds to a speed of 4,000 letters per minute, or in 8 hours 16,000 telegrams of 10 words with an average of 6 letters, assuming that only half the total time is actually used for transmission.

A few weeks ago a 150 km. circuit between Berlin and Magdeburg has been used for transmitting two simultaneous telegrams by high-frequency currents and Hughes' apparatus, in addition to an ordinary telephonic conversation.—K. W. Wagner, *Elektrotechnische Zeitschrift,* Sept. 9, 1920. Abstracted by *The Technical Review.*

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[6] The fact of the independence of the phenomena of discharge of the density of the gas in a high vacuum, which I, myself, had the honor first to discover and describe, is of basic importance in matters of technology. It is through this discovery that we have learned how to avoid the extraordinary lack of uniformity of the early discharge tubes, which we now know were not sufficiently rarefied. Since the technique required for the production of such vacua was likewise prescribed by me, the process was readily carried out. Upon these principles have been produced the modern high vacuum X-ray tubes, whose first instruction owes its origin to me. Furthermore, the sending and reinforcing tubes employed in wireless telegraphy and telephony as well as in ordinary telephony and other domains of science disclose new possibilities of development.

[7] Ehrenhaft has been engaged for a number of years in researches in a peculiar field, namely, that of optical observation upon matter in the form of extremely divided dustlike particles in an electric field. Ehrenhaft believes that he is justified in drawing from his observations the conclusion that the elementary charge of the electron is by no means the smallest negative charge to be found in nature. According to his view point the magnitude generally accepted as the elementary charge of the electron is merely a mean value derived from a great multitude of very various values. This view is contradicted, however, by certain special observations which indicate that the elementary charge of the electron is not a mean value but a fixed magnitude.

In order to call attention to the entirely abstract logical possibility of bringing this last circumstance into conformity with Ehrenhaft's explanation of his experiments that while on the one hand the elementary charge of the negative electron is conceived of as a given inalterable magnitude, on the other hand the theory of a taking up of quantities of positive electricity for the production of smaller charge leads to the idea of a negative electron attached to one of the Ehrenhaft's dust particles. And this is likewise true of quantities of electricity such as are observable in the high vacuum phenomena as elucidated in my concepts of the results of my experiments, and also for this purpose continually divided in smaller quanta than the negative electricity present can be conceived of without involving a difficulty.

Determining Stresses by Polarized Light

Using Transparent Models to Obtain Direct Visualization of the Stress Distribution

By George Weed Hall and Arthur L. Kimball, Jr., M.E.E.

THE efficient distribution of material in designing to withstand stresses in the structure is of prime economic importance, especially in some of the modern mechanical developments, such as airplanes, where weight is a restricting factor. With the widely expanded fields of mathematical computation and investigation of physical properties, engineers often encounter insoluble problems in proportioning unavoidably complicated shapes subjected to varying loads in diverse directions. Sometimes even distribution of static loads cannot be calculated accurately.

Mechanical tests of machine parts or models by duplicating as nearly as possible working conditions and the study of partial failures and fractures, particularly in the more frequent case of rapidly varying loads, serve practically in better disposal of material. The correct detection of causes of failure is, however, sometimes difficult. The quantitative determination of stress distribution and direction at all the various points in machine members is at best an intricate matter. To dispose material in parts without waste and within practical factors of safety at all points constitutes good construction. Obviously modern competitive selling dictates specifically economical designing.

The deductive study of stresses through other than metallic bodies is embraced in the subject of photo-elasticity. This may be defined as a scientific method for determining stresses by transmitting polarized light through transparent models of the members to be investigated. The color effects produced in the model enable stresses to be measured which could not be calculated by mathematical methods.

Models made of glass become doubly refractive when subjected to stress; but nitro-cellulose, celluloid or xylonite, has been chosen for these investigations because of evident advantages. While glass is of crystalline structure and has many physical characteristics similar to those of steel, iron and other metals, its fragility and the expense and labor involved in making specimens are objections. The models also have to be made very thick and the forces applied very great—near the breaking point.

Celluloid possesses all the desirable qualities of glass, may be obtained free from initial stress and can be easily shaped without producing residual stress. It has been proved both mathematically and experimentally that stress distribution deduced from these models show gratifying agreement with stress distributions in all materials obeying Hooke's law, according to which stress is proportional to strain.

Extensive investigations of stresses with nitro-cellulose models have been conducted over a period of years by Professor Ernest G. Coker, M. A., D. Sc., F. R. S., M. Inst. M. E., M. Inst. C. E., and Professor of Mechanical and Civil Engineering at University College, London, England. During the past year Mr. Arthur L. Kimball, Jr., M. E. E., Research Laboratory of the General Electric Company, has been in London for the purpose of studying this scientific work under Professor Coker at the college and instituting similar research here. A special set of apparatus designed by Professor Coker and Mr. Kimball was manufactured in London and has been erected in the Research Laboratory at Schenectady where it is being used for solving some outstanding problems. Professor Coker has collaborated here during the summer in this scientific work, giving his advice and coöperation.

THEORY OF LIGHT

A conception of the nature of light inheres in the comprehension of the behavior of polarized light transmitted through stressed transparent models. Subjectively, light is the sense impression formed by the eye. Objectively, the nature of light is the deepest of scientific research.

The first theories of light were the emission theories, principally the one that light is a stream of extremely small corpuscles which luminous bodies emit and which can pass freely through transparent substances and produce the connoted sensation by their impact against the retina. Sir Isaac Newton championed this hypothesis in so masterly a manner in his "Opticks" (1704) that it held sway until the beginning of the nineteenth century. He, however, had to reject some of the original simplicity of his theory to explain the colors of the spectrum, the equality of speed of propagation of all rays, although it readily accounted for rectilinear propagation.

The wave, or undulatory, theory developed secondly from the trend of mathematical investigation, particularly by Thomas Young and Augustin J. Fresnel. It may be regarded as culminating in the elastic solid theory, or a stationary ether. According to the wave theory light consists of a transverse vibratory motion propagated longitudinally through the ether.

The difficulty of forming an accurate conception of the nature and structure of the ether is very great, and the conventional views concerning it are as yet speculative. It may be considered a hypothetical medium pervading all space, even that occupied by fluids and solids. The functions attributed to it, those of the transmission of light vibrations as well as the production of all the phenomena of electric and magnetic fields of force, exhibit properties different from those of any known form of matter.

The third theory of light resulted from mathematical research of James Clerk Maxwell. The deduction from this hypothesis is that light waves are electro-magnetic, of the same nature as those generated by oscillating electric currents. Yet Arthur Schuster declares in his "Theory of Optics" (1904), "So long as the character of the displacements which constitute the waves remains undefined, we cannot pretend to have established a theory of light." This should be interpreted to mean the real nature of light and related phenomena.

It has been proved the ether transmits waves of every wave length with the same velocity of 300,000 km., or 186,000 miles, per second, which is the fundamental constant at the basis of the theory. That the speed of light does not vary with its wave length has been determined from observation of the variable stars. The situation is different in a refracting medium where the velocity is inversely proportional to the refractive index of the medium, which varies with colors. Ole Roemer first noted at Paris (1676) through observation of Jupiter's satellites, made in different relative positions of the Earth and Jupiter in their respective orbits, that light travels with a definite speed. This has been established at 299,778 km. per second in air and 299,853 km. per second in vacuum.

Monochromatic light consists of a succession of simple harmonic vibrations, the color sensation depending on the frequency. Young and Fresnel explained the phenomena of interference on this basis in connection with the principle of superposition, and from the hypothesis deduced the various wave lengths. Newton's old theory was that a prism actually sorted out the colors of the spectrum,—violet, indigo, blue, green, yellow, orange and red. The new theory is that the prism really does manufacture the colors, the sequence of irregular wave trains of white light being analyzed into a series of more regular trains by the prism.

The range of measured or practical wave lengths of electromagnetic waves is enormous, as illustrated in diagram (Fig. 1), extending from the extremely short X-ray vibrations to the mammoth waves radiated from an alternating current distribution line. The wave lengths, it will be observed, range from less than a hundred-millionth cm. to thousands of miles. It should be considered that there is no discontinuity at limits denoted. Though varying so widely in their manifestations, all these waves are of exactly the same nature and differ only in length. Note the amazingly small range of the spectrum visible to the human eye.

REFRACTION, INTERFERENCE AND POLARIZATION

Refraction of light is the deflection of rays in passing obliquely from one medium into another of different density, or in traversing a medium not of uniform density. A ray passing into a denser medium is bent toward the perpendicular to the surface of separation at the point of incidence, and in passing into a medium less dense is bent away from the perpendicular. The angles between the perpendicular and the ray before and after deflection are termed respectively the angle of incidence and the angle of refraction. The ordinary law of refraction is that the sines of these two angles are in constant ratio, called the refractive index, of the velocity of propagation in any two specific mediums, but naturally it differs for different mediums and depends on the nature of the light employed, or its wave length.

In single refraction the rays are not divided. In unequal refraction of composite light transmitted through a triangular prism, dispersion occurs and the spectrum is formed by the colors arranged in series in the order of their respective wave lengths, or refrangibility.

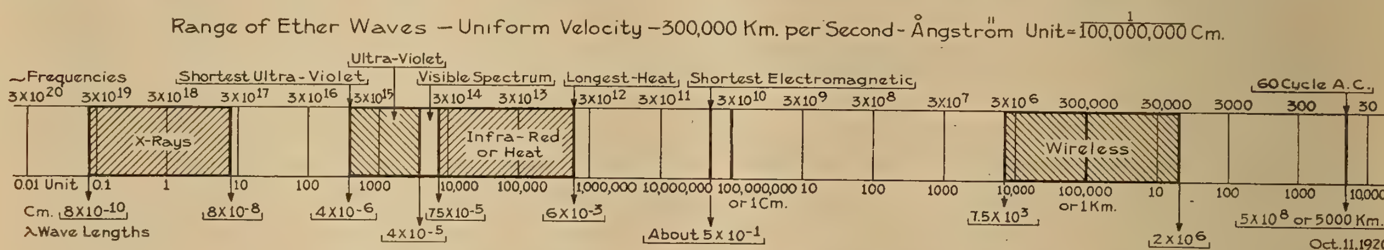


FIG. 1. RANGE OF ETHER WAVES. NOTE HOW SMALL, PROPORTIONATELY, IS THE VISIBLE SPECTRUM

Interference results from the action of two identical vibratory motions that tend to cancel, neutralize or augment each other by a combination of opposite, intermediate or like phases of motion. With monochromatic light this is manifested by dark bands shading into and alternating with light ones, the width of which differs with the color; hence, with white light, where the bands are due to the superposition of various colored bands of unequal width, bands of several colors are produced.

Double refraction is exhibited when streams of light traverse certain crystals, notably a rhomb of Iceland spar, in which the incident ray is split up into two refracted rays vibrating in straight lines at right angles. The waves are said to be polarized, the ordinary in its principal plane and the extraordinary in a plane perpendicular to its principal plane.

A line joining the two apexes formed by the obtuse dihedral angles is called the optic axis of the crystal. Rays passing through the crystal parallel to the optic axis are not doubly refracted, but are in any other position. A plane perpendicular to any refracting face of the crystal and parallel to the optic axis is called a principal plane.

The vibrations are transverse, i. e., perpendicular to the direction of the ray, and all in one plane when light is fully polarized; while common light has transverse vibrations in all planes. Light is said to be plane, circularly or elliptically polarized according to the nature of the path of vibration.

Polarization may likewise be effected by reflection, repeated refractions and diffraction. In rotary polarization, in which the plane of polarization is altered or rotated, the vibrations take two directions, right-handed and left-handed, one gaining on the other in such a way that, on emerging, they join in a plane polarized ray, the plane of polarization having undergone an angular displacement depending on the nature and depth of the polarizing medium used.

Shortly after Newton made his classical investigations of the spectrum (1665), recombining its colors by means of a second inverted prism, Artolinus discovered (1670) double refraction of light transmitted through the Iceland spar rhomb, which he observed in the form of dual images of a single object. Christian Huygens noted an absence of symmetry in the two transmitted beams. The wavelets of the ordinary ray have a spherical wave-front and those of the extraordinary an ellipsoidal wave-front tangent to the spherical at their intersection with the optical axis or a line parallel thereto.

In his "Traité de lumière" (1690) Huygens published an elucidation of reflection and refraction, as well as double refraction, but the last was not called polarization until E. T. Malus observed the phenomenon (1808) produced by reflection; for he attributed it, based on the emission theory, to a kind of polarity of the light corpuscles.

D. F. J. Arago discovered circular polarization in quartz in 1811 and, with Augustin J. Fresnel, made many experimental investigations which culminated in the formation (1816) of the Fresnel-Arago laws of interference of polarized beams. One of the most important of these figures in explaining color effects produced by stressing transparent models.

The rotation of the plane of polarization by quartz was also discovered by Arago in 1811; if white light is used, the colors change as the Nicol rotates, a phenomenon termed by Biot "rotary dispersion." Fresnel regarded rotary polarization as compounded of right and left-handed circular polarizations. Sir David Brewster conducted polarization research over a wide range. In 1816 he made the remarkable discovery that transparent materials while stressed become likewise doubly refractive, the subject of the investigations by Professor Coker and Mr. Kimball.

COURSE OF LIGHT THROUGH THE POLARISCOPE

James Nicol devised in 1828 the famous Nicol prism, which facilitated greatly the determination of the plane of vibration of polarized light. The prism consists of a long rhomb (equilateral parallelogram with oblique angles) of Iceland spar, an anisotropic medium, i. e., possessing different properties specifically for the transmission of light along lines of different directions. The acute angles are naturally 71 degrees but are cut down to 68 degrees. The rhomb is cut in two along an axis and the portions are then cemented together with Canada balsam.

The incident ray of light entering one face is divided into the ordinary and extraordinary rays. The ordinary ray is totally reflected out sideways at the interior surface, while the extraordinary ray is transmitted through the crystal and emerges from the opposite face parallel to the incident ray.

The polariscope arranged by Professor Coker and Mr. Kimball operates with a 4-in. diameter beam from a Mazda lamp projector, with condenser, as this lamp gives a more constant beam in focus than an arc projector. The polarizer consists (Fig. 2) of a graduated cylinder, with necessary lenses, in which the first Nicol prism is mounted so that it

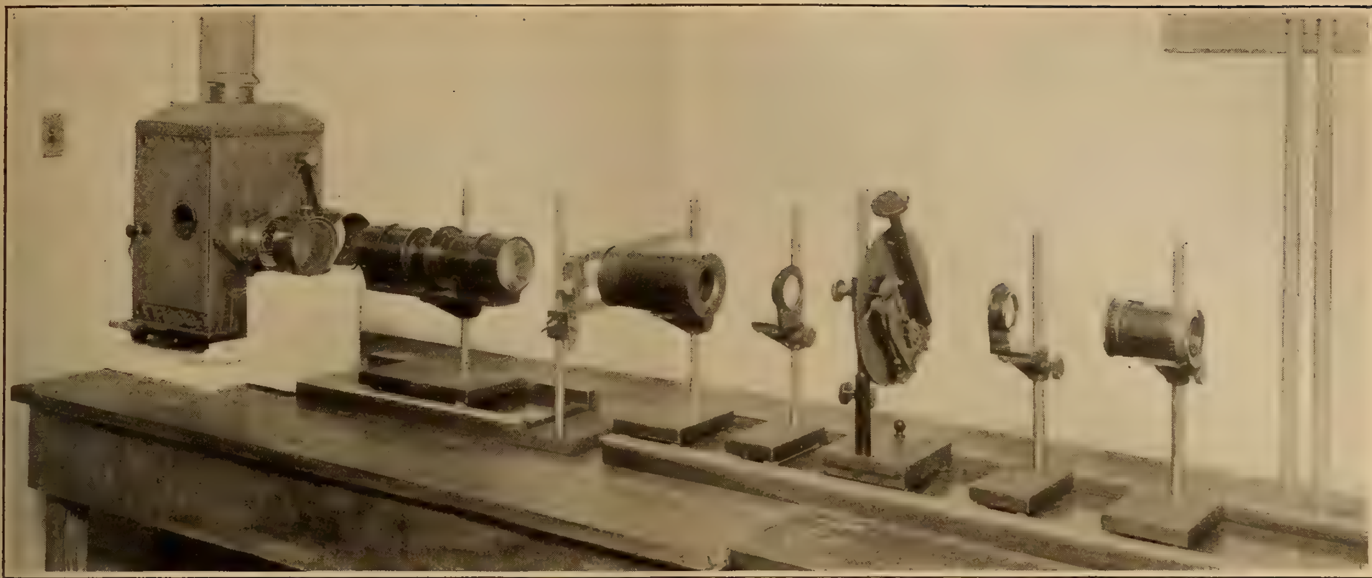


FIG. 2. OPTICAL SET FOR DETERMINING STRESSES BY POLARIZED LIGHT

can be turned about the incident ray as an axis. A second Nicol prism similarly mounted at the proper distance constitutes the analyzer. A filter water screen is placed immediately in front of the polarizer to absorb heat from the incident rays.

The transparent members to be stressed are held between the polarizer and analyzer in a specially screw-operated frame for subjecting tension, or in other apparatus specially devised by Professor Coker and his assistants for applying uniformly such stresses as compression, internal fluid pressure or shear. The light is finally thrown upon a screen for observation of the resultant interference colors.

Ordinarily light from the polarizer is plane polarized. Circularly polarized light is employed, however, to pass through the stressed model; for it can be resolved into any two components at 90 degrees, and the color interference effects are therefore independent of the angular position of the model, depending only on the stress intensity.

Circularly polarized light is obtained from the plane polarized stream by passing it through a quarter-wave plate of mica of such a thickness that it introduces a relative retardation of a quarter of a wave between the component streams within it. The direction of vibration of the most retarded stream is called the axis of the plate. By placing the plate so that this axis is at 45 degrees to the primitive plane of polarization, the light becomes circularly polarized. Conversely, a second quarter-wave plate is located in the analyzer with its axis at 90 degrees to that of the first plate for bringing the circularly polarized light back into a state of plane polarization.

According to one of the Fresnel-Arago laws of interference of polarized light, two streams of light polarized at right angles and coming from a stream of polarized light interfere as common light when brought to the same plane of polarization. But in order to produce interference in this case, it is necessary that one component shall be retarded one-half wave length with respect to the other.

When circularly polarized light vibrating in one 45-degree plane passes through a transparent model, say, of a rectangular plate, and no stress is applied, a black field shows on the screen. If it is subjected, say, to tension stress, which may be represented across any plane section by the vector of an ellipse having the major axis corresponding to the maximum principal stress (p) and the minor axis to the minimum principal stress (q), the effect of the stress is to divide the polarized beam into two component rays vibrating in planes at right angles in the directions respectively of the principal stresses.

Although in the same phase at entry, the beams travel at different velocities through the plate, one being retarded more than the other and with a retardation for simple tension and compression directly proportional to the stress applied and to the thickness of the plate. The function of the analyzer is to select the components of both waves which are parallel to the principal plane of the Nicol and, when brought into this same plane, interference ensues causing the color sensations. The required colors are produced when the final plane is perpendicular to the primitive plane.

Thus the color effects appear entirely from applying stress to the transparent model and in obedience to the Fresnel-Arago interference law stated. As soon as one of these two rays is retarded one-half of a wave length behind the other, the two cancel and the color corresponding to that wave length is cut out. The other colors partially or wholly remain. As the stress is changed a different color is cancelled, and so the remaining color changes as rays of different colors are retarded differently by any given stress. Hence, as the stress in the model is progressively increased, one color after another is progressively cut out, leaving a different color effect on the screen in each case due to the colors remaining. When the stress becomes of a complex nature, the colors vary accordingly from point to point in the image on the screen.

Why stressed transparent materials become doubly refractive is not known. It is a demonstrable self-evident fact, just as moving a conductor through a magnetic field generates an electro-motive force. Neither can we explain electricity. The identity between light waves and electro-magnetic waves, however, is established.

SOLUTION FOR STRESS DETERMINATION

When we apply gradually, say, a tension stress, to a strip of nitro-cellulose, the colors appear in the following order with approximately relative values, the color cycle being repeated in nearly the same manner for twice the stress intensity: black, 0; gray, 3.5; white, 5.5; straw, 8; orange, 10; brick red, 10.5; purple, 11; blue, 13; second order, yellow, 18; red, 21; purple, 22; and so on into subsequent orders.

Where the stress is simple tension or compression from a given system of loading in its own plane, the intensity can be read off immediately from the color scale. If a ring is cut in one side and the specimen loaded like a hook, it is severely stressed at its horizontal section and the distribution across this section consists of tension and compression stress only. From the stresses read off at the various points of the section we may plot curves of distribution.

In most cases the stress distribution is of a complex nature; but it is known that any case of stress in the plane of a plate

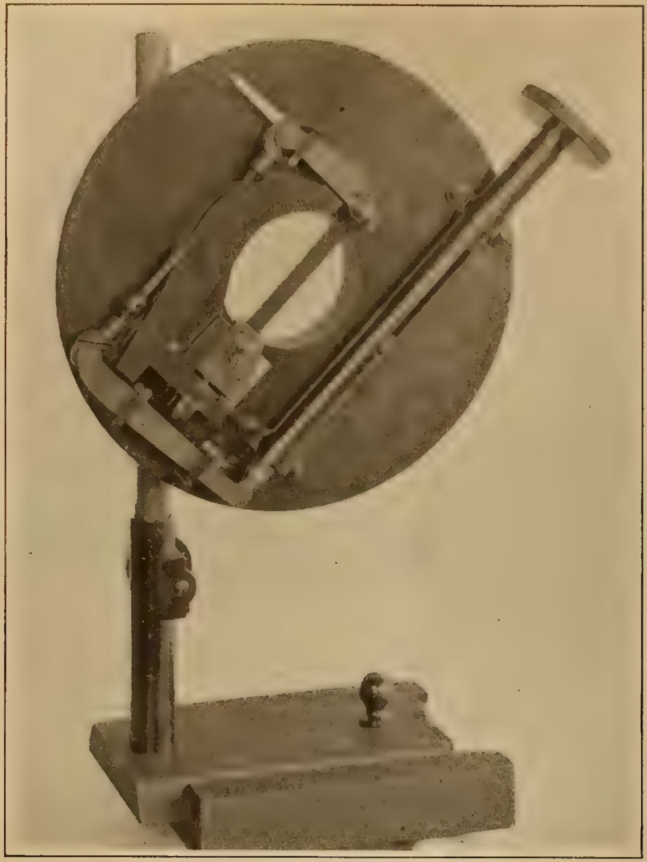


FIG. 3. CALIBRATION FRAME FOR USE WITH OPTICAL SET

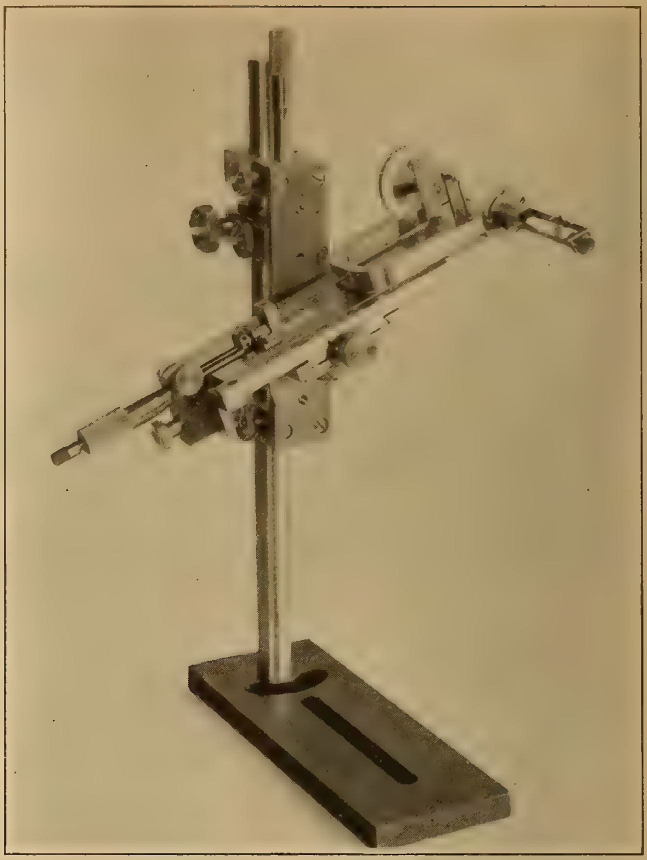


FIG. 4. EXTENSOMETER FOR DETERMINING CHANGES IN THICKNESS OF SAMPLES

can always be represented by two principal stresses at right angles, the determination of the directions and magnitudes of which at all points solves the stress distribution.

It is first necessary to establish the respective directions of the principal stresses to plot curves. As previously stated, the stressed material causes one of the retarded rays to vibrate in the direction of the major principal stress and the other in the direction of the minor principal stress. The state of stress at any point may be represented by a pair of stresses at right angles through the point.

Between crossed Nicol prisms a stressed plate shows, in general, dark bands marking the positions of all points where the directions of principal stress correspond to the axis of the polarizer and analyzer. These change as the optic axes are rotated and a series of bands is obtained.

If simple tension stresses are uniformly applied perpendicularly, the principal stresses (p) and (q) may then be represented by two systems of lines intersecting at right angles, in which the intensity is indicated by the spacing. Hence, any character of stress distribution in a plane can be represented conventionally by two systems of orthogonal curves, which will be spaced according to the manner the external loads and boundaries of the plate dictate. Across narrow necks they naturally will be crowded together, where the stress intensity increases, and will sweep out again toward paths parallel and perpendicular to similar sides of the plate.

An understanding of the relation of the color effect to the principal stress intensities at any point is next involved in the solution of the problem.

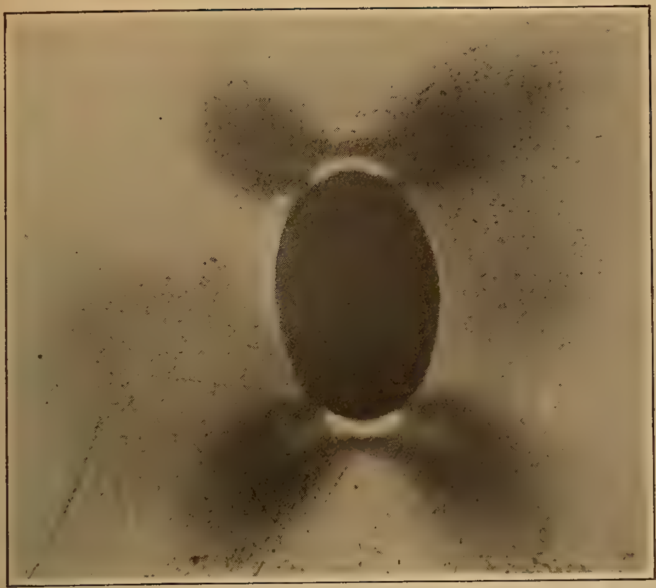
If we superpose two similar tension or compression members, or interpose a double thickness, subjected to the same unform stress intensity and showing exactly the same color effects, the resultant color effect is that produced on a single member under twice the stress, directly proportional to the intensity and to the thickness of the plate. If two equally stressed tension or compression members of the same thickness are crossed, the common area shows a dark field, indicating that they neutralize. An equally stressed tension and compression member placed with the direction of the stresses parallel also give a dark field. Thus, tension or compression stresses in the same direction add their optic effects, and in directions at right angles substract them.

We may therefore always represent the color effect of the stress at any point by the difference (p minus q). Exact quantitative results of the value of the stress difference may then be obtained by matching the color effect at a given point with that on a simple tension or compression member of the same material stressed a known amount, measured by a calibration gauge (Fig. 3). The zero method of establishing optically the stress intensity at any point in the model by balancing to a dark field with the known stressed member is in general more accurate than color occular comparison.

Deductions from the color effect are usually sufficient for stress determination at all edges and boundaries where the greatest intensity exists in most cases. For a complete determination, however, measurements of the change in the thickness of the plate are taken into account by a delicate extensometer (Fig. 4) having a calibration refinement to one-millionth of an inch, observation of which is obtained by mirrored reflection. Stress causes a change in the thickness of the plate proportional to the sum (p plus q) of the principal stresses in its own plane.

If, say, both stresses are tensions, there will be a lateral contraction of (p plus q)/mE, where m is the reciprocal of Poisson's ratio and E the coefficient of elasticity. A fair value of E for xylonite is 300,000 in pound and inch units, and m has a value of about 2.5, so that for each 1,000 lb of stress intensity the corresponding lateral contraction of plates of the usual one-quarter inch thickness is 1/3000 of an inch. Inasmuch as the value of E is much smaller for this transparent material than for a metal, accurate calibration with the extensometer can be done more easily.

In calculating shear stresses it should be considered that the optic effect produced is proportional to the maximum shear (p minus q divided by 2). The directions of maximum shear stress incline exactly at an angle of 45 degrees to the princi-



FIGS. 5 AND 6. THESE ILLUSTRATIONS WERE MADE FROM COLORED PHOTOGRAPHS OF TRANSPARENT MODELS WITH TENSION APPLIED IN A HORIZONTAL DIRECTION

The elliptical holes show a maximum stress intensity at the top and bottom

pal stresses (p) and (q) at all points in a plane stressed member.

It is not difficult to explore the whole of a plate stressed in this manner by determining both the difference and sum of the principal stresses at a sufficient number of points on the lines of stress so found. Curves of the directions of the principal stresses and contour curves of magnitudes may then be plotted; therefore, the problem of stress distribution in a plate stressed by forces in its own plane can be solved completely experimentally.

The permanent strain resulting from stressing materials beyond the elastic limit produces such a change in the structure that the laws of optic behavior of elastic materials cannot be applied exactly beyond the elastic limit. It, however, may naturally be inferred that the overstress relations between nitro-cellulose and ductile metals exhibit very similar properties. As the yield point is reached there is a local tendency to stress equalization across the section, which increases as the load is applied. This indicates the value of ductility in preventing excessive strains. Stress strain conditions both in nitro-cellulose and in steel may heal with rest, particularly in hot weather. Recent investigation demonstrates that failures in ductile materials may result from shear. Failures in experiments with transparent models are immediately indicated by the material becoming opaque.

Colors on a stressed model are arranged in bands or figures in conformity throughout with the distribution of stress intensity. If a transparent beam is subjected to a uniform bending moment, observation discloses that the stress varies uniformly from a maximum compression at the under side to nothing, a neutral axis, at the center, and that it then changes sign and increases uniformly to a maximum tension stress at the upper side, exactly the same as in a metal beam similarly loaded. Models of complex shapes exhibit multiform figures (Figs. 5, 6 and 7) of variegated colors changing with varying stresses and thus giving direct visualization of the actual stress distribution.

FIG. 7. THIS ILLUSTRATION SHOWS A NOTCHED BEAM WITH TENSION APPLIED IN A HORIZONTAL DIRECTION

The corners of the notches are points of sharp local stress

QUESTIONS OF POLARIZING X-RAYS

This subject is a glance into the future. Scientists dream of the time when we can record observation of stresses due to static loads in metal models, or even in the machines themselves running at full speed, through polarized X-rays.

The Braggs have demonstrated that X-rays can be reflected by means of crystals, and recent experiments by Professor Davis of Columbia University have actually attained over 40 per cent reflection with perfect crystals of Iceland spar. X-rays cannot as yet, however, be refracted, polarized completely or deflected by a magnetic field. Very short and non-periodic electro-magnetic impulses of the ether, they can ionize gases, i. e., render them electric conductors, but they are not bent in passing from one medium into another.

A medium, or method, which will polarize X-rays completely has yet to be discovered. That such a discovery will unfold tremendous utilitarian possibilities is obvious. That it is not impossible has been demonstrated by the researches of Barkla, who has noted what might be termed a partial polarization of the secondary rays amounting to about 15 per cent.

This "polarization" is still more marked if the secondary radiation is excited by means of secondary rays. But it is only the scattered secondary radiation which shows any "polarization"; the characteristic secondary radiation emitted by the body is quite unpolarized.

CONCLUSION

Stress investigation by means of polarized light presents a vast and intensely interesting field for useful exploration. The magnitude of the possibilities for practical application, which are held out by this new method of visual determination of stresses commands deservedly the serious attention of structural and machine manufacturing industries.

Metal Substitutes—I

Use of Various Metals and Alloys in Germany to Replace Those Made Scarce by the War

By General Director Albert Wuerth

With Annotations by C. Powell Karr, Ph. B.

The present article translated from the German periodical Stahl und Eisen, *April 1st, and 29th, 1920, should be of unusual interest to foundrymen and to everyone who manufactures or makes use of alloys in his business. It is a mine of useful information and an astonishing revelation of the inexhaustible patience and marvelous skill of the German metallurgists. The translator, C. Powell Karr, who is a member of the engineering staff of the U. S. Bureau of Standards, has added appreciably to the value of the article by his bracketed notes and criticisms.*

Editor.

The effects of the scarcity of raw materials caused by the war are sufficiently well known so far as individual cases are concerned. Here we shall describe the ways and means that had to be devised to reduce the disadvantages resulting from the inevitable inferiority of the substitute materials and will show from the results achieved and the experience gained with new raw materials, what promises are held out for future usefulness in times of peace.

The principal manufacturing in question may be grouped in three principal divisions: 1. Driving engine and pump construction; 2. Steam-jet apparatus; and, 3. Heating construction.

1. Engine and Pump Construction

At first engine construction will be dwelt upon and with it the manufacturing of submarine engines, followed by a brief description, because they were built years ago in times of peace.

According to the construction of the submarine, its spacious crank-shaft housing and frame had to be made of a special bronze that possessed surpassing mechanical properties. The resistance to rupture of this bronze ranged from 48 to 56 kg. per square mm. (68,272 to 79,651 pounds per square inch). The elongation had to run from 18 to 30 per cent. In 1917, test bars were cut from the crank-shaft of an average sized submarine, from the marine office in Poland. An official report of the test gave:

Resistance to Rupture Kilograms per square Millimeter		Elongation Per cent	
62.4	Average 61.2 or (87,047 lbs. per square inch,	22.5	average 20.83 per cent
59.0		20.0	
62.1		20.0	

At the beginning of 1915, on account of the scarcity of metals, these crank-shafts or housings and their frames, were made of cast steel which, without special improvements, were immediately available, therefore they led to economy in structural shapes. In the larger submarine engines steel castings were introduced, which was an improvement because they produced greater rigidity in the frame. The only disadvantage was the increased difficulty of working.

All the screws, screw-plugs, etc., which formerly were made of bronze or other copper alloys, now had to be made of iron and be protected from rust by the sherardizing process. Generally the majority of all the parts that were formerly made from copper alloys, now had to be made of sherardized iron, a process which gives scarcely more than a measurable coating of zinc. Another part, like breech-bolts, which had been made of light weight aluminum castings, was now made of thin galvanized iron plates.

The voluminous copper conductors were replaced by steel pipes. In part the piping had to be galvanized both outside and in. The solidly adhering zinc was soon destroyed by sea water and by sea air holding salt in suspension; also, on account of the high electrolytic solution-pressure of the zinc (zinc being electropositive toward iron), the galvanizing coating had to be replaced by lead. The lead coating had the disadvantage that the mechanical deposit did not firmly adhere to the iron, but became detached through outward influences. Hence it was found that the piping must be provided with two metallic coatings which corresponded to the melting point of the deposited metal and these metals, one by one, were applied fiery hot. The galvanizing was followed by the leading process. The application required great dexterity of treatment and a careful maintenance of the temperature range. It was partially established that zinc and lead are soluble in each other.

The main bearing bushings and caps were made from steel or from pressed rolled iron instead of bronze. A further economy in tin was attained in a particular manner. The bronze bushings with the strongest kind of levers (valve-gearing, reverse-gearings) were, until the war, made of bronze containing about 15.5 per cent tin. These bronze bushings and journal boxes were now economized in the amount of tin used by the substitution of a 30 per cent tin-poor alloy, and this was accomplished by resorting to the chill-casting process. (It is singular in this connection that no suggestion occurred to them, nor was there any attempt made to substitute a phosphor tin alloy for tin itself, which would have afforded them the means and power of hardening the copper alloy used, without lowering its tensile strength or other valuable physical properties so greatly in demand, and at the same time save their tin for other necessary purposes. Also it did not occur to them to substitute the well-known nickel-bronzes for the tin bronzes which have been used with success in this country for many of the castings hereinafter mentioned.)

The chill casting process was resorted to in order to secure the hardness reached by a high tin alloy, according to Heyn and Bauer.[1] The mechanical behavior of copper-tin alloys (bronzes) in a great degree depended upon the heat treatment to which they were submitted. An essential effect is produced, namely, by the greater or lesser rapidity of the cooling after casting. A rapidly cooled bronze is, for example, considerably harder than the bronze of the same composition which has been allowed to cool slowly. This fact enables the foundryman to increase the hardness of the alloy, applicable for many industrial purposes, without the necessity of increasing the tin content to accomplish the same purpose. The bronze cast in a chill shows a much closer grain than the sand-cast alloy. A brass alloy above 67 per cent copper is not affected in the same manner.

These bronze bushings with a tin content of about 10 per cent, according to the method of working and the set-up used in the levers by means of a conical punch under heavy hydraulic pressure on their upper surfaces, compressed the metal to a close-grained structure. Neither copper nor brass with more than 67 per cent copper is altered by quenching; they are neither harder nor softer, nor more malleable, as has been erroneously asserted and maintained of copper.

[1]Mitteil.a.d.kgl. M. concerning the influence of heat treatment of bronze for hardness—Berlin, 1910, p. 344.

Metal improvement,[2] such as hardening of hot-rolled brasses, containing 67 per cent copper, as well as of steel and of bronze, should be based upon chemically determined alterations or transformation of structure or upon the appearance of polymorphic varieties which are entirely lacking in copper and higher grades of brass.

Like the copper-tin bronzes, aluminum bronze may be hardened. Experiments were made with aluminum bronze and also with the binary copper-aluminum alloys, but unfortunately their physical properties did not come up to the test requirements for engines. The scarcity of tin, but not of copper, was completely shown here. The already known alloys containing up to 7 per cent aluminum may be hardened. An aluminum bronze with 10 per cent aluminum, for example, after being heated through several degrees up to 800°C. and after quenching, gave a Brinell hardness of 100 to 260.

Close to the substitute metal was a white metal with a tin content of 78 per cent. Experiments with a bearing metal having a composition of 42 per cent tin, 42 per cent lead, 2 per cent copper and 14 per cent antimony, were not completed, but for all that the investigation was further continued. From bronze, only single parts were on hand (their stuffing boxes with high pressure compressors).

The circulating water pump bodies and similar parts of engines were made of cast iron in place of gun-metal and bronze, with considerable reconstruction, such as the reinforcing of their walls. Only pistons and sliding-ring bushings were still made of bronze. The further use of cast-iron as a substitute metal and the difficulties that followed its use, will be mentioned later. An engine or motor made with all of the above described construction and material alteration, appeared plain and dull in comparison with the bright and shining motors made in times of peace. The commutators and new adjustments were proceeded with without great difficulty.

2. STEAM-JET APPARATUS

Greater difficulties were met with in the changing of this apparatus. The use of substitue metals based on many practical experiments for this work was unconditionally necessary. Before the war it appears that only in rare cases were substitute metals used. The points of view which led to the necessary use of copper, gun-metal, bronze, hard lead, etc., are:

1. The lessening of corrosion, in consequence of mechanical, chemical or electrolytic influence and hence:
2. Ready working of the apparatus.
3. A simpler construction.
4. Simpler and cheaper methods of working.

However, since then, under the pressure of circumstances, the failure in the use of substitute materials must be taken into account, notwithstanding the fact that substitute metals were earlier introduced into the construction of a vast amount of steam-jet apparatus. In this apparatus there is considered chiefly steam, water, various acids and gases which are under either high pressures or great velocities, or both combined, whether they are the driving or the driven substances.

In the best known steam-jet apparatus, the injector, cast-iron was used in place of gun-metal for the inlet or outlet delivery nozzles. This usage showed that a normal iron as well as a special iron was not sufficiently resistant toward steam and hot water, under the action of pressure and high velocity. The inner contact surface of the nozzle was so much eaten away that the apparatus worked wastefully, and finally some of them failed (became choked up).

Experiments with aluminum alloy nozzles of various sorts were not yet conclusive, it appears however so far as known, that only aluminum bronzes with about 90% copper and 10% aluminum promised any satisfactory results, but of course this effected a saving in tin but not in copper. (In this connection it is singular that no effort was made to substitute Monel metal for bronze in the nozzle construction of injectors. They had nickel in almost unlimited quantities, they had sufficient copper and the iron necessary to make the combination, even if they did not have the ore from which it is smelted in America. By adding a small amount of chrome iron to the combination, an ore of which they had an abundance, they would have been able to make a substitute for the bronze they needed, which would have fulfilled their most severe conditions.)

Moistening devices for air and similar purposes by which the spraying apparatus could be adjusted, were constructed of gun-metal. At first the casing of the old model and adjustments were cast from the so-called zinc-bronze, while the nozzle itself was made of gun-metal. The zinc body, however, was incapable of use, since it fractured under action and turned out to be porous. After alterations the principal casing was made of cast-iron and the inner plug for the water inlet was of zinc, screwed in. Both of the air nozzles were constructed of zinc-bronze. In use, they showed very soon an uneven wearing surface, so that the spray diffusion was unequal, and drops formed. The inequality of surface (corrosion) resulted from the formation of zinc hydroxide. A better arrangement had to be provided to afford in some measure a better spraying service.

The baffle-plate of a pulsometer is of very simple construction; it is generally made of gun-metal. Baffle-plates of zinc-bronze of various compositions cracked after several hours of service or were bent at the lower edges. The later construction of cast-iron turned out better. Copper and brass tubes could not be replaced by zinc tubes as the first experiments clearly proved.

Steam-jet heaters, for certain places and purposes, were made of gun-metal; in the course of time when zinc-bronze was substituted, the operation of the substitute turned out to be a complete failure. An example is referred to in which a marked outward corrosion was perceptible; on the inner surfaces the reaction of the mixture of steam and water developed the decomposition to a greater extent and after several days of continuous service the apparatus became worthless. The fractures in the reinforcing flanges, like the pulsometer and the tubes, showed also that zinc-bronze under high water and steam pressure, had no longer even a claim to soundness. (Manganese bronze castings if made in the right manner, of suitable composition and poured at the proper temperature would have been a good substitute for zinc-bronze for the resistance to corrosion which they would offer for the service they had to perform.)

Very instructive is the evolution of the oil heater, as it was used during the war. The casing and cover of the oil heater were formerly made of gun-metal from the highest grade of marine bronze. As a substitute for the cover, steel was chosen. Difficulties arose with this usage, the cover was then made of cast-iron with its walls reinforced; very soon however it cracked in service. After further construction a steel tube was substituted for the brass tube. The cover was made from ingot-iron disks; the casing on the other hand was made of special steel blocks. Since about 90% of the material was wasted in the working it became too costly a method to use. The riveting of the parts gave rise to many difficulties, so that the case was constructed of plates, which at the bottom and along the longitudinal seams were welded together. The other bottom was riveted to the welded casing. Upon the basis of the experiments in autogenous and oxyhydrogen gas welding methods the cases were for a long time welded together with both bottoms closed by welding. Also the oil supply exhaust whose application to the flame offered many awkwardly accessible places, was welded; so that finally the oil pre-heater from one part to another became concave.

Both of the zinc-bronzes mentioned have been submitted to the most searching and exacting tests, however, in order to obtain the most suitable metals possible which were required for the apparatus that had to be used.

[2] J. Czochralsky-Heat Treatment of Metals, *Giesserei-Zeitung*, 1915, Oct. 1, p. 289.

In combination with the oil pre-heater stands the oil and water gages. Up to the beginning of the war the head of the apparatus was made of gun-metal, particularly of marine bronze. At first substitute steel was employed. In consequence of the intricate core, however, the cast pieces were always useless. Since this method was impracticable, the general form idea was retained; nevertheless, in the alterations the inner channel was taken care of in such a way that it could be bored out, with the head remaining of cast steel, cast solid without a core. This solution also brought no improvement. As a first result it led to a construction that could be built up from ingot iron (mild steel) plates 42 millimeters thick. From this a feasible remodeling was necessary upon the basis of which the head should consist of two parts.

Almost the same development made as in times of peace, in gun-metal, led to the use of exhaust valves for hot oil. When manufactured from cast steel, in the same way for the same purpose, the design became infeasible and the largest part of the castings had to be rejected. At first after the reconstruction by swaging of the driving valve with the corresponding bored work the result was unobjectionable.

It may here be mentioned that all machine construction, chiefly, as also the jet-driven apparatus which in the swage shaped parts found greater use through the experience gained in the war, because of the more accurate measurements of the swaged parts, brought about a great relief from the laborious work of the hand-forged parts. To this came a further reduction in the cost of manufacture, except where quantity production was required. (This admission seems to be almost incredible and is explainable on the supposition that it was impossible for them to build shaping tools, dies and other duplicating machinery fast enough for production on an unlimited scale and also that trained mechanics had been drafted from their forces for the war, so that skilled labor became conspicuous by its scarcity.)

In the forging of the work this was a transition from the shop work to production by machinery, as in the foundries was the transition from bench work to machine molding, by which likewise the quantity production required was not to be considered.

Therefore it can be stated that the extent of the use of substitute metals and substitute construction in jet apparatus as contrasted with general machine construction could be of only a short duration.

3. HEATING CONSTRUCTION

In heating construction metal saving was effected in valves and cocks by the substitution of cast-iron, but especially with a reconstruction of the same. In the larger valves there was a smaller compressed valve-seat and a stem-guide at hand, while the remaining parts were executed with substitute metals; the casings built of cast-iron, the arbors and bolted joints of wrought iron. The same construction proved acceptable for the jet apparatus construction of the necessary normal values. (In this connection it is to be wondered at why the so-called "dur-iron" or high silicon iron was not given a careful try-out for such parts as did not require a high tensile strength, but did call for great density and resistance to the corrosion by acid gases or liquids; perhaps they were secretly tested, but for technical reasons no mention was made of them.)

In the section so far described, which held itself up to the very edge of utility manufacture in times of peace, there now came to be considered the direct manufacture of war-products, which in the department of handicraft, were so far completely unknown. To this work belongs:

1. Construction of bake-ovens.
2. Manufacture of horse-shoes.
3. Manufacture of cold-worked grenades, their machining and methods of filling.
4. Manufacture of gray cast-iron grenades, their machining and operation of filling.
5. Manufacture of projectile fuses, their machining and the labor required.

Of the chemical, physical and metallurgical manipulation the most instructive indeed of all the operations undertaken was the manufacturing of these fuses. In the following text some of the details of the many experiments undertaken, and the difficulties encountered in the application of them to produce practical results will be described. From the necessity of using gun-metal in the manufacture of fuses, the main difficulties were met with in the metal casting and the subsequent shop-work required for their finishing.

(In this connection it is advisable to attempt an explanation of what is referred to in the text concerning "Marine Bronze" and "Gun-metal." According to their own group of metallurgists, scientific men and foundrymen who met in convention in Germany on May 22nd and September 10, 1919, on the question of adopting rules and regulations concerning the nomenclature of Non-ferrous Alloys, they admitted that a great deal of confusion prevailed in the trade as to the actual meaning and correct usage of these two terms. So far as can be learned from their discussions Marine Bronze consisted of an alloy of 85 to 87% copper, 11 to 9% tin and 4 to 6% zinc; that 87% copper, 9% tin and 1% zinc was regarded as a soft bronze, and 85% copper, 11% tin and 4% zinc was regarded as a hard-Marine bronze. Now "Rotguss" or gun-metal had a composition of 86% copper, 10% tin and 4% zinc. In the text mention is also made of zinc-bronze, which is not mentioned in the discussions at the convention; this, however, is the same as the American zinc-bronze, as they frequently adopted foreign names for their alloys, and has the composition of 88% copper, 10% tin and 2% zinc. It will be seen by a close comparison of the compositions that they all belong to the same order of bronzes, with the distinction, that the "Marine Bronzes" were the only ones that steered clear of the transition line between the *alpha* and *beta* formations, and from which solid solutions could be expected and therefore the German metallurgists were correct in their views that it was the best alloy of the group.)

In motley succession the panorama reveals the continuous alteration of the alloys required and these alterations provide the foundations upon which were built the substitution of other metals for the slight changes introduced in the most favorable alloys by which were secured either greater economy in the use of substitute metals or in securing better working conditions.

The development that ensued is comprehended in light of the constant struggle between onerous conditions and stringent requirements. The latter may be considered in three groups:

1. An endeavor to secure the necessary economy in certain metals by reason of their scarcity.
2. Relation to each other on account of the required physical properties, such as tensile strength, hardness, stability in the air and against the deformation of their structure by the process of aging.
3. Requirements of a good working capacity, such as susceptibility to rapid machining and hydraulic soundness to overcome the natural tendency to porousness induced by carelessness in pouring.

The basic metals were aluminum, copper and zinc in varying succession. In their stead were considered experimentally such metals as magnesium, cast-iron, or mild steel. As a result of the reciprocal effect of the basic metals there came into consideration such metals as tin, copper, aluminum, etc., according to the purpose for which they were employed as the source of improving or entrenching their physical properties.

Before describing the course of the development pursued in the adoption of these clever expedients it is necessary to refer to some accessory means of application as follows:

For all the alloys employed in the foundries, graphite cruci-

bles were chiefly used in times of peace. The extraordinary quantity of fuses that had to be poured made it necessary to use enormous quantities of graphite crucibles. Since spathic graphite (about the only kind found in Germany and even that is defiled by the presence of iron oxides or silicates) had become a scarce material early in the war, use was made of iron crucibles alone, of special structure, for all the alloys to be described later aside from the brass alloys and others of a higher melting point. The great quantity originally on hand was done away with shortly. At the beginning the difficulties that arose in consequence of the destruction of the crucibles caused by the combination of the fluid metal charge with the iron walls of the crucible, by reason of the chemical affinity of the zinc in the alloy for the iron of the pot at high temperatures, lay in the formation of an iron-zinc alloy and the mechanical solution of the iron particles, by which the edges of the costly machining and finishing tools were immediately destroyed.

Within the crucible as well as in the firing space were excrescences of a specially refractory encrustation. The stirring tools were not made of iron, but of implements coated with a refractory clay. (They could not get artificial graphite stirring rods such as are used in American foundry practice.) The metal bath had to be stirred with extraordinary precautions and the temperature range controlled by means of a pyrometer. (The persistent control of their foundry products by means of the accurate use of pyrometers, not as a laboratory caprice, but as a faithful friend in need, should teach every American foundryman who ignores this marvelous tool that he is neglecting its assistance to his own costly disadvantage.)

In consequence of the war's consumption, measures had to be taken to save a great many thousands of crucibles. On the other hand many foundries daily cast ten thousand fuses; up to the end of 1917 these were cast exclusively from graphite crucibles, because it had been held impossible to get good results from iron crucibles.

The fuses were cast in chills with a high sprue or waste-head, that without an injurious cross-sectional change passed into the casting and provided a sufficiently large feeding head. The function of the waste-head was to remain hot and fluid longer than the casting, thus, exhausting as much as possible its original form as a feeder, and at its upper part it had to consist of either a thin skin or frail enclosing walls that were encased necessarily by asbestos to reduce the heat radiation as much as possible. There were some cases even where the waste shrink head surrounding the chill had to be especially heated.

Along with the formation of the shrink heads the fuses were provided with chill molds; the pouring temperature of the alloy, the chilling temperature, the kind of casting, the method of cooling the casting, the chemical, physical and metallurgical tests of the same, etc., were the important points to be considered in the production of uniformly good castings. No point was too minute to be despised. Underlying every part of the manufacture, accompanied by the most exacting supervision at every point of departure, so far as it was possible to maintain the composition of the alloy, it assured the obtaining of fuses that were free from objections.

It is still to be observed in the following descriptions of the finishing and splitting tests of each fuse alloy that the simplicity of them, all on account of the same form of fuse for all purposes, is taken as a basis of comparison. In reality the various systems of fuses of the field artillery projectiles have increased. Since their shapes do not deviate essentially from one another the critical examination of the usefulness of the alloys are such that no false conclusions could be drawn.

The first fuse alloy specified was composed of 92% aluminum, 6% tin and 2% copper. This alloy, in times of peace, was used for projectile fuses. The casting of the fuse and its machining offered no difficulties. Tensile strength values, analyses, etc., were not called for. The large amount of tin (6%) was considered the cause of its excellent machining properties, i.e., the making of a good chip in the turning or milling operations.

The lack of aluminum and of tin led to experiments to lessen the amount of both metals in the composition of the fuses, and in an emergency to introduce in their place other metals that could be supplied from the home country. These experiments showed that the reduction of the tin and the aluminum in the composition made it difficult to machine some portions of the fuses; especially in the workshops the best methods of machining were not completely known. The reduction of the tin was the strating point of the limitations that became known. Such an alloy was composed of tin 5.88%, copper 2.21%, lead 0.11%, zinc none, iron 0.5%, silicon none, aluminum the balance. The pouring temperature was from 720C. to 730C. (They would have met with better success had they poured at a temperature just below 700C.) The chilling temperature was from 290 to 310C. Tensile strength was from 8.7 to 9.3 kilograms per square millimeter (12,374 to 13,228 pounds per square inch).

Microstructure, splitting and bursting tests show a fine crystalline structure. The crystal aggregates are both light and dark, tin-rich and copper-rich solid solutions. In the shrinkheads the piping is clearly visible.

The additional experiments as to the scarcity of tin and aluminum were supplemented by experiments with zinc, since zinc was already known and tried out as a substitute for aluminum, but also, because during the war zinc was a metal obtainable in Germany in almost unlimited quantity. Besides, metallographic researches had shown that the structure of most of the aluminum-zinc alloys were homogeneous throughout, hence castings they were suitable for fuse. The solubility of both metals, considering the ensuing degrees of heat, were complete and altered but a little by a reduction of the temperature, so that very dense castings without segregation or abnormal crystal formation was to be expected. From the micrographic structure, cleavage and bursting loads, there is perceptible a crystalline structure of the combination of an *alpha* and *gamma* solid solution. For all the investigated aluminum alloys the crystalline structure is characteristic. Under the microscope (magnification 50 to 60) as also in the copper-poor zinc alloys, the cellular form of structure is recognizable. Through the earlier work of Bénard and Quinke,[3] a cellular formation before the appearance of crystallization is probably to be accepted. The cells—also known as "foam cells"—develop with the freezing of the crystals, however, in such a way that several foam cells previously formed can unite to form one crystal. In the above examples the single crystals appear to have been formed within the cellular walls.

In order to determine the largest amount of zinc permissible there was examined, at first, practically, the known alloy of about 30% zinc and 70% aluminum. It proved to be, however, completely worthless, since, on account of too great a hardness, it was in the normal quantity unworkable. Descending step by step with the amount of zinc used, without the addition of other metals, it was left open, besides, to no objectionable quantity production. On this score there must be considered still an addition of tin. A reduction of the tin to below 4% with simultaneous addition of from 12 to 15% zinc at the cost of the aluminum displaced by it, at that time, no longer allowed for the proportion of a profitable quantity production, or had given rise to a case of production because of the slight experience had in the working and finishing of the fuses. Micrographic structure, cleavage and bursting tests revealed crystal aggregates with the changing compositions.

Addition of lead to these alloys from a metallurgical stand-

[3]Bénard,—Cellular whorls in a film of the liquid—Thesis, Gauthier-Willars, Paris, 1901; Quinke,—The Transition from the Solid to the Liquid State. *Proc. Roy. Soc.*, 78, 1906. p. 60; see also Martens-Heyn: Metallurgical Material for Machine Construction, Berlin, 1912, pp. 204-5.

point was unwarranted, and also led to no tangible results. Further experiments, on this account, were confined to reducing the aluminum by corresponding replacements by zinc, with the intention of keeping the tin down from 4 to 6%. This alloy was found to be completely serviceable. It contained: tin 4 to 6%; copper, highest at 2%; zinc, maximum, at 15%; aluminum the balance.

The alloy was found to be quite acceptable as early as the end of 1914 even with respect to its machining qualities. Thus this fuse alloy preceded the development of the aluminum fuse alloys, since it was not until about two years later that there was any official demand for aluminum alloys with a decreased tin content and the addition of greater amounts of zinc though in somewhat altered form. Finally, after about three years, tin had to be excluded altogether from the fuse alloys. On account of the ever growing scarcity of aluminum a complete change of attitude on this question was soon noted at that time for the production of fuses.

(*To be continued*)

AIR REQUIRED TO BURN A POUND OF COAL *

By C. C. Phelps

Pounds of water evaporated per pound of fuel, or per pound of combustible, is the telltale of a boiler plant's efficiency. This ratio, in turn, depends primarily upon another ratio—that of pounds of air supplied to burn each pound of fuel. If the air-fuel ratio is large, the evaporation will be low, and conversely, if the air-fuel ratio is small the evaporation will be high unless other factors interfere. It should always be the aim to burn fuel with the minimum quantity of air that will give practically complete combustion. The indication of such result is, of course, high CO_2, as shown by the table.

WEIGHT OF AIR PER POUND OF CARBON IN THE COMBUSTIBLE AS INDICATED BY CO_2 IN THE FLUE GAS

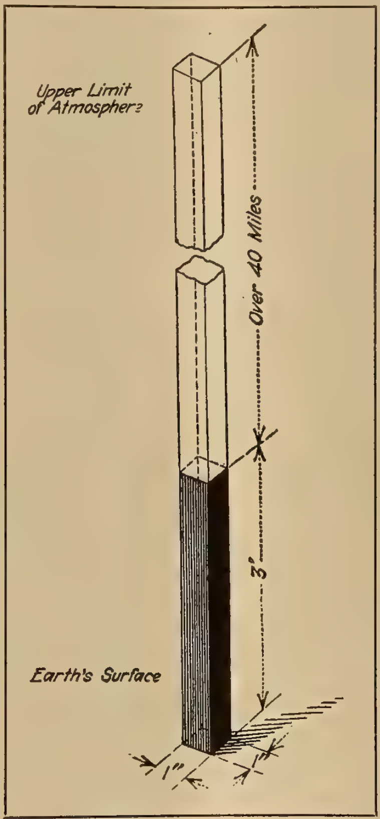
Per Cent CO_2	Pounds of Air	Per Cent CO_2	Pounds of Air
21	11.6	10	24.4
20	12.2	9	26.1
19	12.8	8	30.5
18	13.5	7	34.8
17	14.3	6	40.7
16	15.2	5	48.7
15	16.2	4	61.0
14	17.4	3	81.3
13	18.7	2	121.8
12	20.3	1	244.0
11	22.1		

It is a general mistake to give more thought to the fuel than to the air supply, in spite of the fact that from fifteen to fifty or more times as much air as fuel enters the boiler furnace. Air being invisible, many engineers and firemen do not appreciate how much of it they deal with daily.

A pound of carbon, the preponderant element of fuel, requires 11.6 lb. of air in theory for its complete combustion. Actually, it requires more because there must be 40% excess air to provide for the difficulty of mixing the air and fuel completely while burning. Therefore coal containing 10 per cent ash and burned with 40 per cent excess air would require about 14.6 lb. of air per pound of fuel.

We know that the pressure of the atmosphere on each square inch of the earth's surface at sea level is 14.7 lb. That means that all the air directly above a square inch of the earth's surface weighs 14.7 lb. The earth's atmosphere is estimated to extend up into the sky for a distance of over forty miles from the earth's surface. Such a column of air, then, one inch square and over 40 miles in height, would be just about sufficient to completely burn a pound of coal if it could be brought in contact with the fuel. The pound of coal would occupy a volume of about 36 cu. in. or a column 3 ft. high with a one square inch base. Although the forty-mile (or more) column of air certainly makes the little column of coal look insignificant in comparison, it must be borne in mind that this proportion represents best conditions and in practice two or three times as much air is frequently employed, to the detriment of high efficiency.

A similar mass of air on the ground would, of course, occupy a smaller volume because of the greater and uniform density of the air at the earth's surface. Nevertheless that figure is correspondingly impressive. One pound of air at 62 deg. F. and atmospheric pressure occupies 13.14 cu. ft. Therefore, 14.6 lb. of air, the amount required to burn a pound of coal, would occupy 192 cu. ft. of space. Multiplying this figure by 144 gives 27,648 ft. (or 5¼ miles) which is the length of a column of air 1 in. square, of normal atmospheric density, required to burn one pound of coal (about 36 cu. in.). This air represents 9,216 times the volume of greatest quantity of coal which it can burn, namely, 36 cu. in.



AIR REQUIRED TO BURN A POUND OF COAL WOULD MAKE A COLUMN 1 IN. SQUARE REACHING TO UPPER LIMITS OF THE ATMOSPHERE

*Reprinted from *Power*, Nov. 2, 1920, p. 703.

ELECTRIC HEATING DECLARED IMPRACTICABLE

No present possibility of using hydroelectricity for heating purposes is seen by C. A. Magrath, formerly Fuel Controller of the Dominion of Canada. For this conclusion Mr. Magrath gives three reasons. First, although the potential capacity of Canada's water powers is enormous, they are insufficient to heat electrically its present homes, to say nothing of future growth, and at the same time to meet the light and power requirements; second, the tremendous cost of the power plant and of the power transforming and transmitting equipment—all of which would of necessity be in use at the same time in cold weather and none of which would be needed for heating in warm weather—puts electric heating beyond practical consideration; third, the proposal to use electrical energy for heating is based upon unsound scientific principles. Electricity should not be wasted; but in the ordinary electric heater the heating element is in the form of resistance, and all the energy is thus of a low type.

To heat electrically 20,000 houses each needing 25 hp. at the same time would entail a power plant and transmission installation of 500,000 hp., Mr. Magrath estimates. This is twenty-five per cent more power than the total capacity of the three large power companies located at Niagara Falls, Ontario.

If there were so much water power available that there was no economical use for it, now or prospectively, there might be some excuse for advocating electric heat, the former Fuel Controller concludes; but when ten times as much coal can be saved at every point where electric motors replace steam-driven machines as could be saved by the same amount of energy used for electric heating conservation efforts should be centered on the electric power question—not on the visionary project of electric heating.—Reprinted from the *Electrical World*.

Research and Boards

Need of Establishing Laboratories to Study the Problems of the Lumber Industry

By Ovid M. Butler

Assistant Director of the Forest Products Laboratory at Madison, Wis.

THREE hundred years ago the first sawmill in America was built in Maine. It antedated by forty years the first sawmill in England, which was promptly demolished by a mob as a device of the devil. Although the early New England mill fared better, it is safe to assume in the absence of complete historical records that its advent was greeted with suspicion, ridicule, and skepticism. Nevertheless, its success as an improvement over existing hand methods is attested by the fact that, in the years immediately following, a dozen or more similar mills appeared throughout the colonies.

For 200 years this type of mill, with slight improvements, prevailed. It was operated by water power and consisted merely of an upright sash-saw with a capacity of from one to two thousand feet daily. The belief that it represented the perfection of lumber-manufacturing machinery undoubtedly prevailed until early in the 19th century, when the application of steam to sawmills in New England, and the successful introduction of the circular saw (about 1860) multiplied by four and five the output of the water-power sash-saw and opened an era of invention in logging, milling, and wood-working machinery. Within a few decades these inventions lifted lumber manufacture from 250 years of crudity into one of the most remarkable, useful, and diversified industries of our economic life.

ONE COMMON WAY OF SKIDDING LOGS IN THE EARLY DAYS

Thus, a steadily increasing knowledge of steam-power and machinery has been the great productive force in lumber and wood manufacture and in wood utilization, and out of hit-or-miss studies, experiments, failures, successes, a mass of diversified machinery has been evolved which, with bewildering rapidity, converts the standing forest into a multitude of finished wooden articles or their component parts. Overriding skepticism, ridicule, and often hostile opposition, this mechanical science has carried forward irresistibly the whole lumbering and wood-working industry and made it the second greatest of the nation. It has made wood available in a greater variety of useful articles than any other material with which man comes in contact, and by so doing it has created greater wood demand and wood supply.

Our forefathers used the crude water-power sash-saw and laughed at efforts to improve it, because their minds failed to grasp and apply the theories of steam power and circular saws. Once those theories were given practical consideration instead of skeptical ridicule, however, an invisible power transformed within a single generation our whole wood-using world. Theoretical nonsense, new-fangled or long-haired ideas, pure or applied science, scientific or industrial research—all are familiar terms that may mean much or nothing. The outstanding fact is that from the beginning of time the creative source of this transforming power has been the mind of man, stimulated by inherent desires or worldly rewards to do new things and to find better ways of doing old things. Despite prejudices which may prevail with respect to the word, let us call this functioning of the mind "Research"—organized or unorganized, systematic or unsystematic, scientific or unscientific—and think of it merely as the acquisition of knowledge and its application to the advancement of industry and society.

It is through research that "fools" and "wise men" have evolved the diversified forest products of today—lumber, pulp and paper, naval stores, tannin, ethyl alcohol, fiber silk, preservatives, etc.—products which touch the daily life of every man, woman, and child of our country. It is said that a hundred years ago a chemist boiled up some cellulose in the form of an old shirt, with sulphuric acid and amazed the world with the discovery that the cellulose was converted into sugar. In any event, laboratory research has developed the commercial processes whereby thousands of gallons of 95 per cent grain alcohol are now made from yellow pine sawdust. From one cord of waste wood approximately 20 gallons of the highest-grade alcohol found on the market today is reclaimed.

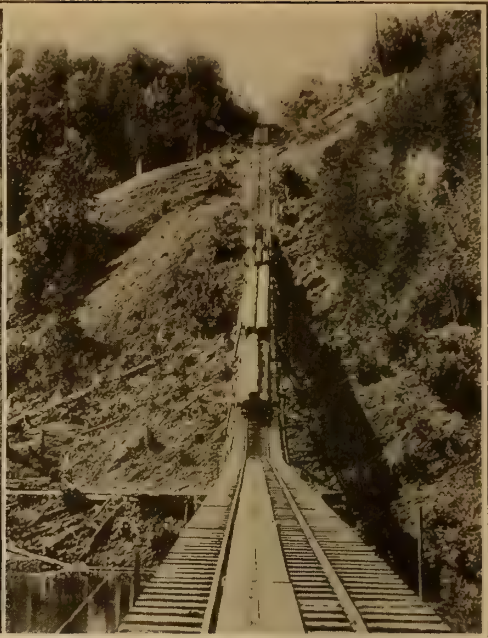
For centuries man has searched for a practical method of extracting the fibers of the wood. It was not until the middle of the 19th century, however, that Burgess, after several years of unsuccessful experiment, discovered that by boiling wood in caustic alkali at high temperatures a good pulp could be produced. After the close of the Civil War, Tilghman, experimenting with a solution of sulphurous acid to dissolve the intercellular matter of wood, made the further discovery that it yielded a pulp suitable for paper. These individual and fundamental researches revolutionized the whole industry of paper-making within a few years and laid the foundation of an industry whose annual output in America today is many millions of dollars and whose product has made us the greatest readers and the most enlightened nation in the world. Within a period of twenty years, this youthful industry reduced the price of newsprint paper 75 per cent to a point which has enabled our newspapers to reach the staggering daily circulation of about 27,000,000 copies, or one copy every day for every family in the land.

In the same way every forest industry can be traced back to some form of research, rough and uncoördinated though its origin and development may have been. In dollars and cents alone these allied forest industries are steadily enhancing the commercial and economic value of forests. Here is an estimate of how a few of them stand today:

Industry	Annual Value of Products
Pulp—Chemical and ground wood	$300,000,000
Distillation, hardwood and softwood	100,000,000
Naval Stores	60,000,000
Veneer	100,000,000
Miscellaneous—Chemical, oils, etc.	10,000,000
Tannin	40,000,000
Wood preservation	50,000,000
Containers (wood-fiber and veneer only)	200,000,000

STEAM SKIDDER WHICH ASSEMBLES LOGS FROM HALF-MILE CIRCLE

THE OVERHEAD SKIDDER SIMPLIFIES THE HAULING IN OF LOGS IN ROUGH COUNTRY



RAILWAY INCLINES ARE QUICK MEANS OF TRANSPORTING LOGS DOWN A MOUNTAINSIDE

Almost a billion dollars added to our national wealth annually! These figures, fragmentary though they are, stand as a credit account in favor of research—unorganized, haphazard, individualistic research in an industrial field in which it has never been given general encouragement or recognition.

The lumber industry for years has been cutting its cake greedily and eating the heart of it. The rest has gone to waste, plate and all, where land fit only for growing forests has been stripped and left unproductive. No one ventures to assert with precision what this waste aggregates annually, for estimates run into staggering figures. The woods and mill waste alone has been placed at about 62,000,000 cords annually. This gigantic waste has been justified by the industry on the ground that it is unmarketable. The industry asserts that it cannot practice forestry because stumpage values are too low and too uncertain to assure profitable returns. Stumpage values are, of course, determined by what can be obtained from standing timber, whether boards only, or boards plus pulp, tannic acid, ethyl alcohol and other by-products. There is reason to believe that, in the waste incidental to present lumbering practice, there are values and profits greater than those realized on the material marketed; but these values can be salvaged only through systematic and well directed research.

An example will serve best to illustrate how utilization growing out of forest research, fragmentary though it is today, enhances the values of stumpage and of forest land. On a 30,000-acre tract in Pennsylvania, averaging 18,000 feet of hemlock and 4,000 feet of scattered hardwoods, the following utilization has been developed: Hemlock logs are manufactured into lumber and the hardwood logs into barrel-heading and staves, except the small amount of cherry which goes into material for cabinet work. The hemlock logs are barked before going into the sawmill and the bark is sold for tannic acid. Dead hemlock and hemlock tops go into pulpwood. The best slabwood and edgings are sawed into lath, and the rest is made into kindling wood. The waste from the hardwoods, including tops, large limbs and defective logs which in most operations are left in the woods, is utilized by a destructive distillation plant in the manufacture of wood alcohol and acetate of lime. By this utilization, the stumpage owners have increased the value of their stumpage by 35 per cent. Such complete utilization is profitable only under specially favorable market conditions, but the absence of such conditions in no way precludes opportunities for research to develop new processes or new products which would place forest waste elsewhere on a marketable plane.

As one reviews the benefits to such industries as cotton, steel, concrete, meat-packing and agriculture, it is not difficult to understand why within recent years research is being more and more recognized by the progressive industries as a business asset, an invaluable resource lending itself to profitable organization and capitalization, and why it has been given a definite and recognized industrial status.

But what of the lumber manufacturer, the man whose business it is to make boards? Unfortunately, there are some lumbermen who still think of lumber only in terms of trees and boards and of research only in terms of whiskers and microscopes. They fail to appreciate the fact that, in worshipping the band-saw, they are paying tribute to a symbol of research. They are apparently unmindful of the fact that the lumber industry, despite its wonderful mechanical development, awoke suddenly a few years ago to a new and insidious competition—a competition wholly from without and sharpened with the deadly accuracy of intensive, well-directed industrial research—which challenged the industry's knowledge of its own product and speedily found out and played upon its weaker side. Today substitutes have replaced wood to the extent of eight or ten billion feet annually and are increasing that figure at the rate of a half-billion feet or more each year.

Considering the ages through which wood has been used, it is a strange anachronism to find that the weaker side of the industry is its lack of knowledge respecting its own forest products, the mechanical, physical, and chemical properties of the various species of wood. Figuratively, the industry, by the force of spontaneous mechanical research, has pushed its manufacturing artillery to the front-line trench of progress; but it has woefully neglected its ammunition. The production of more boards will no more solve the future problems of the lumber industry than the production of "duds" will win future wars. While it may change ledger figures for the year it won't sell lumber during the next period of depression when selling charts show orders and shipment consistently below production.

The great board capacity of the lumber industry is indeed a liability of variable dimensions; it is a cost which must be written off. As production decreases, the board price to the public must increase. Low production with its high-unit prices stimulates inroads of other materials as substitutes for wood. Where the value, adaptability, and serviceability of these sub-

stitutes have been determined by intensive, organized research (as they are coming more and more to be) it will be increasingly difficult for the plain board to "come back" when investments in place force production in excess of demand.

The making of plain boards is a business proposition and the manufacturer who sells them at less than the cost of production is obviously performing a critical operation on his business and is helping to undermine his industry; though probably to no greater extent in the long run than the manufacturer who puts boards on the market at a cost of ten, fifteen, or twenty per cent greater than is necessary, and is thereby merely inviting competition by creating markets for a cheaper substitute, antagonizing the public against the industry in general, and stimulating research on the part of the substitute competitor, to an extent which will never be known until a "research inventory" is as much a part of the industry as the "stock inventory." No assertion is made that the cost of making boards is ten or twenty per cent higher than it should be; but the point emphasized is that, in the absence of research, the industry does not and never can know the possibilities of reducing costs.

Some of the more progressive industries have adopted the slogan, "Business Follows Service," which is tantamount to saying that service precedes business. In other words, service must first be developed upon the sound basis of determining within lines of close accuracy the adaptability and serviceability of the product. Research is the grist-mill of such service, because it grinds in terms of definite and proven rather than preconceived or rule-of-thumb standards. The business or industry whose methods and products are worked out, advertised, and sold upon a well-organized and coördinated policy of research is the hardest possible competitor especially for a business or an industry not supported by research practice. In short, before wood markets can be permanently stabilized and held, the industry must be assured that it is producing, advertising, and marketing its product as scientifically as its substitute competitors.

Of the five leading manufacturing industries of the United States, the lumber industry is the only one that does not maintain a research laboratory for the scientific study of its products and of its manufacturing and marketing methods. A number of the stronger associations, appreciating the need of work along this line, have employed a limited number of specialists; but the only commercial research laboratories receiving the financial support of the lumberman are those in other industries. The graves of empty food cans at the rear of every cook shanty bear mute witness to the truth of this statement, for in providing his camps with canned food the lumberman is contributing his tithe to the research laboratories of the National Canners Association. Similarly, when he installs a special piece of electrical machinery in his mill or in his home, he is supporting in dollars and cents a research laboratory maintained by the electrical company. When he elects a State assemblyman who goes to his State Capitol and votes a substantial appropriation for the State agricultural experiment stations, he is supporting research and usually getting good returns on his money. In his own business, however, research as an investment seems to be persona non grata.

There are few industrial fields in which the opportunities for profitable dollars-and-cents research appear greater than in the lumber and wood-using industries. Aside from the work done by the Government and a few universities, which is woefully limited because of inadequate appropriations, the lumber industry stands conspicuous by the absence of a research program. From the cruising of the timber, prior to purchase or cutting, to the writing of the advertisement which aids in marketing the lumber, there are possibilities for improvements, which under the analysis of research should yield profit, stability, and strength to the individual lumberman and to the industry. If, for example, the shingle manufacturer could write into his advertisement a guarantee that his shingles had, by a certain treatment, been rendered fireproof, it would help his sales and the whole shingle industry. If the writer asserted to the average lumberman that by simple treatment his sawdust could be converted into a palatable and nutritious cattle food, he would undoubtedly be set down as a theorist and a dreamer, yet research has, within the past few months practically establish that fact.

Individual lumbermen probably recall wakeful nights during which they have endeavored to formulate plans for utilizing their waste; but where markets for raw waste have not been available, their mental efforts have in most cases been in vain, and not infrequently they have squandered good money in trying to carry out their ideas. It is certain that failure to make any great progress in developing waste utilization by realizing on intrinsic value in the wood itself is due primarily to the ineffectiveness of haphazard, individual efforts by men trained in lumber manufacture but untrained in chemistry, wood technology, and the methods of the research engineer and forester. Without this technical personnel, the industry will ever stand unprepared and unable to assume its rightful place in the casting and progressive development of a wise and fair National Forest Policy of which research in forest management and forest utilization is the foundation.

An evening spent in reviewing the progress of industrial research in this country should convince the most skeptical that there is something worth while in it. Take, for example, the Portland cement industry—foremost competitor of the lumberman. To scientific studies and tests the general manager of the Portland Cement Association attributes the reinforced concrete building of today and other innumerable articles of concrete not on the market ten or fifteen years ago. The rate of progress of this industry in productive wealth reads like a great gold discovery. During a period of twenty-

AN OLD SAWMILL SUGGESTIVE OF EARLY METHODS

A MODERN MILL CUTTING 100,000,000 FEET ANNUALLY

five years, the value of the industry's annual production advanced from $439,000 in 1890 to $74,000,000 in 1915; in the ten years preceding 1915 the value of the industry's raw product increased almost 300 per cent. Yet men in the industry view their progress as merely at the threshold of concrete's possibilities.

Perhaps the one company in which research has been made a part of its business to a larger extent than in any other is the E. I. DuPont de Nemours Company. This company developed its first research laboratory in 1908, at which time it was spending $220,000 annually. Today the company has a number of large laboratories, and in 1918 was spending $2,000,000 annually in research work. The chemical director of this company has stated that from 1912 to 1915 the company spent $1,200,000 on research and effected a saving of $14,000,000—a handsome profit, however one may look at it. These figures speak significantly for research as a profit-bearing investment.

The first coöperative research within an industry undertaken in this country was by the National Canners Association in 1913, when the research laboratories of that association were organized. The canning industry, like the lumber industry, is composed of relatively small individual plants; and problems are largely common and general, so that individual companies cannot afford to undertake research on an extensive scale. Results under a broad program of coöperative industrial research have been so successful, however, that the work has been gradually enlarged and extended from year to year. No event in history has called attention to the value of industrial research so conspicuously as the war just closed. Since the signing of the armistice, many industries which had not heretofore given thought to the potentialities of organized research from the standpoint of common business needs and protection are taking steps to provide money and facilities for intensive coöperative work along this line.

Few lumbermen can afford, individually, to undertake extensive research, because of the inherent character of the industry. Most effective and far-reaching benefits will come through united and coördinated programs of regional research, which the industry as a whole will support as a part of a national program of coöperative research. Three broad fields of opportunity are open: (1) The establishment of laboratories directed and operated either exclusively by the industry or in coöperation with the National Research Council; (2) The establishment of research fellowships with recognized research institutions, universities, or National Research Council and Government laboratories; (3) Specific contracts or agreements with commercial or non-commercial research organizations qualified to perform the character of work required.

Lumber associations are today spending from a few cents to as much as $2 per thousand feet for advertising and promotion purposes. Over a period of years, 10 to 15 cents per thousand devoted to research would, it is believed, yield higher and more permanent returns and render far greater service to the industry and the public. Second in national rank, the lumber industry should have a research laboratory or at least a research program worthy of its position and its needs and with adequate financial support.

GIVING PLANTS MEDICINE

By S. Leonard Bastin

The statement that a sickly maidenhair fern has been given a new lease of life by the administration of cod liver oil is not at all surprising. During the last few years it has been shown that plants often derive a great deal of benefit from suitable medicines. Now and again plants suffer from a kind of anaemia which manifests itself in pale green foliage, and lack of color in the flowers. This trouble is largely remedied by the use of iron. Water, which has been made rusty with iron is employed, or even iron filings are worked into the soil round the plant and a speedy change in the health of the plant takes place. The foliage assumes a deep green shade and the flowers develop a strong color. Where the amount of iron is large surprising alterations will sometimes be seen in the colors of the blossoms. Thus, now and again, pink flowered hydrangeas will bear blue blossoms under such treatment.

Alcohol has a stimulating effect on many plants. White-flowered primulas and sweet williams were given small doses of alcohol for several days and, at the end of the period, the plants started producing blooms of a bright pink shade. In some way the alcohol brought into activity the latent color in the petals of the flower. The medical treatment of the plant does not merely consist in giving doses at the roots. A weak solution of sulfate of iron applied to the foliage and even the fruits of a tree will act almost magically. This chemical has the power of stimulating the action of the leaves and fruit in drawing sap from the roots. Thus the foliage and the fruits show a development which is greatly in advance of anything that is grown normally. Plants which are kept for the sake of their foliage, such as palms, benefit greatly if now and again the leaves are wiped over with milk, or pure olive oil. The application has a wonderful restorative effect and the leaves remain in a very healthy state.

A few years ago it was discovered that plants were very much affected by anaesthetics. A lilac bush submitted to the fumes of chloroform for two or three hours behaved afterwards in a very astonishing way. Although it was the middle of winter the bush soon after it had been chloroformed started to develop its leaves and flowers. In some way the deep sleep which the anaesthetic induced appeared to take the place of the winter rest period of the plant. Thus, when the bush woke up, it started to grow with all the vigor of the spring. The use of anaesthetics for the forcing of plants into a premature maturity is likely to prove of great value to the gardener.

GRASS AND COTTON

The *Color Trade Journal* for August discusses a discovery by Japan of a new fiber to mix with cotton which promises to bring about a decided change in cheap fabrics in the Far East. The fiber is a kind of sea grass known as sugamo which, under proper treatment, makes a strong thread and is useful for cheapening the material which is now high in price. At present the annual value of raw cotton imports to Japan is about 300,000,000 yen, and if the proposed mixture proves successful this large import of raw cotton can be reduced.

There is said to be no difficulty about a sufficient supply of the grass, which is found in abundance along the shores of Japan. The botanical name of the plant is *Phyllospadix Scouleri*. It is an evergreen about one-eighth of an inch to three feet in width, sometimes sixteen feet in length, and thick, somewhat resembling our kelp. The use of this weed in cotton spinning has just begun and was first tried in making material for horse blankets where success has led to the consideration of its use in other fields.

The secret of the process of preparing the grass is to know how to remove the outer casing of the weed, and this process has been patented. The procedure is said to be somewhat as follows: The dried plant is first boiled in lye for two hours and then allowed to cool. This weakens the skin, so that it comes off without resistance, when the material is washed in water and boiled again, bringing it just to the boiling point for half an hour in water mixed with rice bran. The fiber remaining after this treatment looks like cotton from which any remaining particles of the sheath are removed by rinsing.

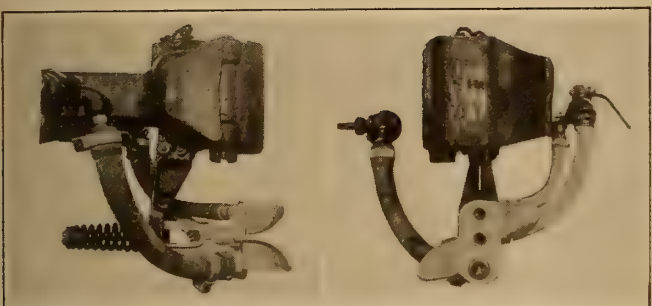
It is claimed that cotton mixed with this fiber produces a stronger thread than when cotton is used alone and that fish nets made from this mixed yarn withstand the wear and the action of the water for three months or more without showing any effects. This is much better than pure cotton thread can do and indicates the possibilities.

The Marvel of Train Control

New System of Automatically Connecting the Air and Steam Hose of Railway Cars

By Robert G. Skerrett

HOW many of us realize just what happens when a powerful locomotive, with a string of cars behind it, gradually gathers headway until it is racing along at the rate of quite a mile a minute? The engine besides pulling a train of heavy Pullman coaches, for instance, is, simultaneously storing up energy in the whole moving mass. That momentum might easily invite disaster if it were not practicable to bring the train to a halt within a span of a thousand feet. Similarly, present-day schedules of passenger service



SIDE AND FRONT VIEWS OF THE AUTOMATIC TRAIN-PIPE CONNECTOR ADAPTED FOR PASSENGER SERVICE

could not be maintained unless the man at the throttle on the locomotive had at his command a medium by which the whirling wheels of his engine and those of the trailing cars could be gripped by brakes and progressively checked. Finally, the management of slower and far more ponderous freight trains would be an exceedingly risky matter when climbing mountain slopes or traveling down steep gradients but for the part played by the automatic brakes fitted to each car.

It is doubtful if George Westinghouse visualized more than imperfectly the potential benefits that would flow from his pneumatic brake, brought out fifty-three years ago. True, he realized that it was quite as important to be able to halt a train at will as it was to give it all of the headway possible with the locomotives of that period; but he could not have anticipated what the engineering fraternity would do in the way of producing steam haulers of greatly augmented power or what the coach and carbuilders would do in the fabrication of heavier, larger and much stronger vehicles. Every mile added to the speed per hour and each ton of amplified load, as time went on, was inevitably bound to increase the operative burden to be borne by the inconspicuous brakes; and the problem laid upon the shoulders of Westinghouse, as long as the air brake was the subject of his intensive study, was to make his apparatus better able to meet the changing conditions imposed by traffic demands and the ceaseless development of railway rolling stock.

His "straight air brake" of 1867, which applied restraining pressure to the wheels by means of air fed directly from a reservoir on the engine, had one outstanding weakness—control was lost if any of the cars became detached through accident. Therefore, in 1872, Westinghouse produced his "plain automatic brake," which was designed to apply instantly the brakes on every car, should the train units become separated through any cause. That invention became the basis of the extremely flexible and ingenious apparatus since brought into being for the retarding and stopping of trains of all kinds. If a train breaks in two today both sections are quickly halted, owing to the compressed air stored in an auxiliary tank beneath each car and to the action of that mechanical marvel, the "triple valve."

As Westinghouse planned, his triple valve stands sentinel between the auxiliary tank and the brake cylinder, on the one hand, and the auxiliary tank and the "train pipe" on the other, by which compressed air is primarily supplied from the locomotive. In order to prevent the auxiliary tank from feeding air to the brake cylinder when such action is not desired, it is essential that a certain pressure be maintained continually in the train pipe. If this equilibrium be destroyed purposely by the engineer or by the parting of the train, then the auxiliary tank dominates the situation and applies the brakes. It should be evident that the air pump on the locomotive must also function automatically whenever the air in the train pipe approaches the minimum prescribed pressure, for, if it did not, leakage anywhere in that part of the system might induce a gradual, if not a sudden, setting of the brakes—in one case adding to the drag or load upon the locomotive and in the latter causing an abrupt and possibly harmful halt.

The automatic air brake permitted the running of longer, heavier, and faster passenger trains, and soon was adapted to freight service. As the years went on, Westinghouse successively improved his braking apparatus to meet the restless advance in railroad engineering and operative practices, but there came a time in the "nineties" when his rare inventive cunning was diverted to other mechanical problems. Then it was that Walter Victor Turner came forward to carry on the vitally necessary work of perfecting and widening the scope of compressed air's part in exercising train control. Turner was, in fact, inspired by accident to pursue the line of endeavor which has made his name famous.

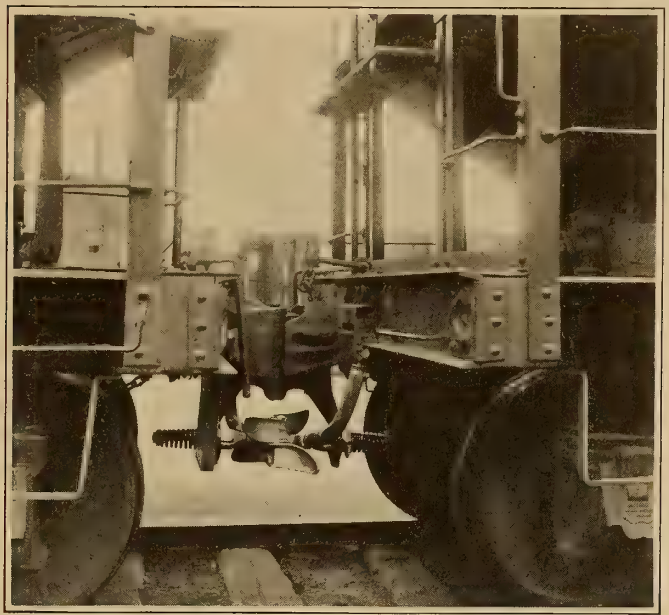
Turner was born in England in 1866, where he was trained

TWO CARS COMING TOGETHER—BOTH CARS AND THEIR HOSE BEING COUPLED AUTOMATICALLY

for the textile industry, but came to the United States and in 1893 engaged in wool growing in New Mexico. While in search of a runaway flock of sheep he happened upon the wreck of a freight train, and obtained a triple valve which had been cast aside from the damaged brake equipment of one of the cars. Afterward, by candle light, he studied that mechanism in his spare hours, and his imaginative mind grasped the potentialities of the art of train braking. When his venture in sheep raising failed, after a few years, he se-

cured employment as a car repairer with the Atchison, Topeka and Santa Fe Railroad, and it was not long before he was actively engaged in overhauling air brakes and even in devising ways to better them. To make a long story short he was "loaned" by the Santa Fe road to the Westinghouse Air Brake Company in 1903, where his rise was rapid.

Between 1903 and January, 1919, when he died, Turner accomplished some remarkable things. He brought out, among these, the well-known "K triple valve," designed especially to facilitate the safe operation of long freight trains. Prior to the advent of that invention, the running of trains of fifty cars was deemed the limit, but his valve made it quite practicable to handle trains composed of from a hundred to a hundred and twenty-five cars. Further, he designed braking apparatus that would enable an engineer to stop his "special," speeding along at sixty miles an hour, within a stretch of a thousand feet, where double that distance had been needed previously to halt lighter passenger trains. The results obtained by Turner were due to the way in which he overcame the sluggishness of the pressure-drop in the train pipe which had hitherto prevented the well-nigh instantaneous application of the brakes upon all of the cars of a long train. That is to say, the brakes would be set on the cars near the locomotive five, ten and fifteen seconds before those on the rear cars would be called into action. As a consequence, when going down hill, the unchecked vehicle would surge violently forward and crash against the cars ahead. Or, when starting or when gathering speed, after slowing up, the wheels on the front cars would be free to revolve while those farther back would still be gripped by the brake shoes. This drag frequently caused trains to pull apart.



AUTOMATIC CONNECTOR INSTALLED FOR FREIGHT SERVICE
There is only one line of hose used—that carrying air for the brakes

By reason of the improvements made by Turner, freight trains of large capacity could be hauled with safety not only up grade but they could be controlled with greater certainty when descending a steep slope. It would be difficult to do full justice to Turner's inventiveness and to the manner in which it stimulated the tide of transportation and the carriage of a vastly increased tonnage of manufactured commodities and raw materials, but it can be said without fear of denial that rail traffic today would be woefully hampered if he had not devoted his rare genius to making the air brake a more positive and flexible medium of train control.

Despite all that Westinghouse did in producing and in enlarging the capabilities of the air brake, and notwithstanding what Turner accomplished subsequently, one feature of the automatic air brake system has held its own for the most part unchanged during the years of evolution under discussion, i.e., the manner of coupling the train-pipe hose between cars. True, this is no longer as crude as it was in the early days when these rubber links were joined by a "butt end" contrivance, consisting of a "male" and "female" element which screwed into each other, and required a duplication of these features beneath both platforms of every coach.

But, even so, the air-brake equipment still employs rubber hose between cars in order to unite the several metal pipes that form the air-distributing system, and these hose lengths must be coupled and uncoupled by hand. Needful as they may be, they are nevertheless weak links in the arterial arrangement by which energizing air is circulated from the main reservoir, on the locomotive, to the very end of a train and through which the impulse is dispatched which summons the separate auxiliary tanks into action. If they leak, if their junctures are not tight and the air finds a way of escape, the intended working of the brakes may be seriously impaired. How? To begin with, it may be impossible, for this reason, to charge to the desired pressure the numerous auxiliary reservoirs located from front to rear of a train: and, what is more, leakage in the hose may prevent the maintenance of a sufficient pressure from end to end of the dominating train pipe. Besides hampering control and thus limiting the number of cars that can be effectively braked when the engineer moves the lever for a service application, this deficiency may invite a disaster when an emergency application, intended to bring about a stop in the shortest distance practicable, is demanded. Again, a leaky hose or coupling may cause the brakes to apply gradually, "creep" as it is termed, without the engineer being aware of the fact until the drag slows up the train or perhaps occasions a break-in-two. Finally, if a hose should burst—a not uncommon mishap—the train may be abruptly and even destructively brought to a standstill. This is inevitable if the rear cars hurl themselves upon the vehicles first arrested.

One fruitful cause of trouble with the linking hose lengths is the failure of trainmen to see to it that these connections between cars are properly made. The demand for quickness in assembling trains and then in detaching and distributing the vehicles later on, gives rise to a measure of carelessness—the railway operatives expecting the couplings to adjust themselves or to disconnect, as the case may be, after somewhat incomplete handling. Undoubtedly, a goodly measure of this hasty manipulation is bred of the fear of bodily harm to which the men are exposed when getting between cars to make or to break the connections of the air hose.

As the use of the air brake widened to meet transportational needs, the objections to hand coupling of the hose multiplied. The inventive skill of the country sought to provide remedies or substitutes; and the United States Patent Office holds abundant proof of the many efforts which have been made to do away with the manual adjustment of these conduits. Millions of dollars have been spent in this quest, for experience made it plain that much might be gained could the air hose be connected and disconnected automatically. In most cases, the primary purpose of the attempted improvement was to facilitate the making up and the breaking up of trains—thereby saving much valuable time; the second aim was to obtain uniformly tight connections; and the third goal was to do away with the need of having yardmen and trainmen get between cars where they were likely to be hurt.

Why the swinging loops of hose have so long been employed should be apparent to anyone who has stood on the platform of a moving train and watched the oscillations of the neighboring cars. As the tracks undulate in following the contour of the roadbed, the contiguous platforms rise and fall more or less oppositely—this play amounting to several inches. Likewise when the train sweeps around a bend, the vehicles surge from side to side—the movement of each car being independent and of a varying dgree, according to the sharpness or to the amplitude of the curve. Plainly, the train-pipe links must be

flexible in order to accommodate themselves to the continually changing motion.

It was because of these conditions, and the difficulties therefore of making an air-tight joint, that so many inventors in this field of railway equipment were baffled. Their apparatus would not give and take sufficiently and, at the same time, maintain air-tight and steam-tight connections. Further, the opposite ports of their devices would not always meet and seal properly when the cars were brought together on a sharp curve or upon a pronounced gradient.

Recently, however, a coupling has been developed that appears to surmount all these several obstacles. It is the invention of Joseph Robinson. He so forms the head of his connector, and the support by which it is carried, that a very considerable difference of alinement can be taken care of. As shown in the accompanying engravings curved "gathering prongs" serve to bring opposing heads to an exact center—port to port, where they remain in intimate contact no matter how the cars may lurch or undulate or surge or pull away from one another when train slack is bunched or stretched in transit.

Tests under the most trying conditions—those purposely designed to tax the apparatus to the utmost—have failed to exceed its powers of accommodation. The reason for this is that each connector unit is suspended upon a universal joint which is so designed as to absorb completely all service shocks and stresses that might tend in any way to destroy the tightness of the joint between the mated heads. At the outset Robinson was frequently told that rubber would never do for the steam port of his connector. He was cautioned that his material would soon wear out and involve repeated replacements to prevent leakage. Further, by way of discouragement, his critics were frankly skeptical about getting tight joints at any time.

Opposition acted as a stimulus, however, with the result that he devised a molded rubber gasket of a very durable compound. This he placed in a supporting annular recess at each port in the connector head so that the front surface of the gasket would come against that of the corresponding gasket just before the joining connector heads were brought metal to metal. The arrangement is such that this union, already under pressure, becomes still tighter the moment air or steam flows through his equipment. Service experience has demonstrated the long life of these gaskets and has emphasized their conspicuous efficiency.

Leakage in the train pipe system calls for a more vigorous operation of the air compressors and hence entails a greater consumption of coal, the cost of which amounts to from seven to eight million dollars per year in the United States alone.

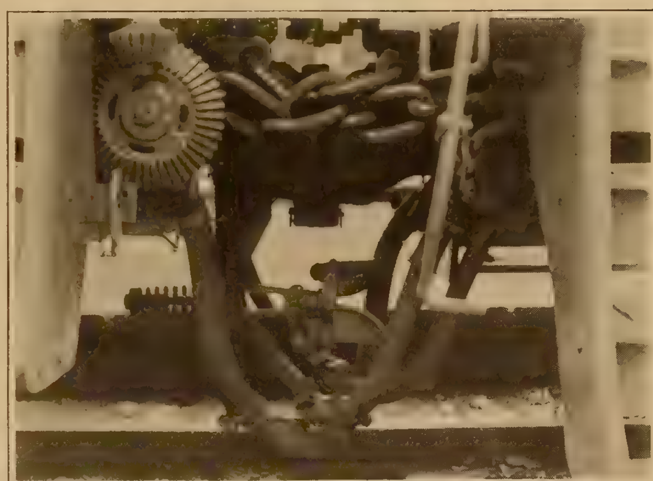
The common brake-hose coupling, provided its packing rings are in good condition and the connection is properly made, will function satisfactorily unless affected by frost. The cold weather of winter tends to stiffen the hose and, instead of yielding without stress to the vibrations transmitted by the cars, nearly all of the motion is centered at the coupling, which is worked somewhat like a hinge, thus causing the escape of the compressed air. For this reason, it is next to impossible to haul full-length trains in the more frigid parts of our country during the winter months; and this means that the number of cars which a locomotive can ordinarily handle must be greatly reduced—often as much as forty per cent. This is indeed a serious matter, especially when the demands upon the railways call for the fullest movement of freight. Further, the frost-stiffened hose cannot be readily coupled and uncoupled by hand, and the time lost in this way adds heavily to terminal charges. It is not at all uncommon, for these reasons, for freight trains to be delayed many hours in getting out of the yards when exposed to severe winter weather.

The new connector functions positively and well under all climatic conditions; it is unaffected by snow or ice. Not the slightest leakage occurs even when the thermometer registers 60 degrees below zero. It is necessary only to bring the cars together to connect the train hose automatically, and, similarly, the drawing of the cars apart automatically separates the device. There is no occasion for railway workers to risk life or limb by getting between the cars to couple or to uncouple the hose. This service on our roads, now generally necessary, occasions yearly the death of scores and the injuring of hundreds among train crews and yardmen.

There is still another loss. Much damage is done to the air-brake system, itself, by neglecting to disconnect the present hand-operated couplings before detaching cars. Not only are the hose lengths in this way ruptured or their fabric weakened so that they burst when least expected, but the metal piping on the cars is apt to be broken or impaired and leaks induced. The automatic connector, by reason of the way in which the hose is joined to it, protects the latter and does not subject it to any mechanical wear or harmful stresses. Therefore, hose that would ordinarily last but a maximum of eight months, will give a useful life of something like three years! Just what this represents can be gathered from the fact that our railroads now spend every twelve months substantially ten million dollars for air and steam hose.

In the popular mind, the automatic connector may not loom large when compared with the somewhat complex and diversified features of the breaking equipment generally, but the railroad man will readily appreciate what the apparatus represents as a dependable substitute for a weak link in a system of control which year by year becomes more and more important in the safe, efficient, and gainful operation of American railways. In the course of the last six years the automatic connector has covered over three million train-miles in Canada alone, where it has met every service need under the severest of climatic conditions, and, accordingly, the use of the connector is being widely extended.

Strange as it may seem, every bit of engineering progress that has given us more powerful steam locomotives, that has called into being longer and more ponderous trains, has come about with little if any regard to the added burdens which these changes were bound to impose upon the braking apparatus.



THE INTERCHANGE DEVICE WHEREBY A CAR THAT HAS THE AUTOMATIC CONNECTOR MAY BE LINKED WITH ONE NOT SO EQUIPPED

The advent and the rapid development of the electric locomotive are hastening the coming of the day when splendid passenger trains, starting from a standstill, may be accelerated to sixty miles an hour within the amazingly brief interval of a minute of time. Then, even more than now, must the man at the lever have every confidence in the braking system at his disposal. Each second must be made to count in arresting that tremendous momentum so that the thunderous mass can be halted quickly if peril threaten. Here it is that the automatic train-pipe connector is destined to play an important and essentially vital part.

DE HAVILAND TWO-SEATER MACHINE FITTED WITH THE NEW HANDLEY PAGE WINGS

Slotted Airplane Wings*

A New Form of Wing of the Venetian Blind Form

INNUMERABLE proposals have already been advanced with the object of improving the aerodynamical properties of aeroplane wings. Up to the present, however, real improvement has been effected solely by varying the conventional wing section. Wings with radically unconventional sections—such as the doubly-cambered upper surface wing applied to the "Wight" seaplane exhibited at Olympia in 1914—have been tried and abandoned. Others have proposed or tried various forms of cellular wing constructions ranging from simple box-kite arrangements to devices resembling a magnified honeycomb radiator. Some of these wings have succeeded in developing "lift"; others have not, and all, we believe, have passed to the scrap heap. Other inventors, again, have been attracted by the idea of arranging two or more wings in tandem. As a more or less logical development of this idea, the Venetian-blind wing has been proposed and tried scores of times, more frequently, in all probability, than any other one form of wing. In view of the innumerable trials and failures with this type of wing in the past, it is distinctly startling to find that, disguise it as we may, the new Handley Page wing, about which so many rumors have been heard, turns out to be of the Venetian blind or slat wing form. Mr. Page and his experts will perhaps not agree with this description of the new wing, but as their own illustration, which we reproduce in Fig. 1, should make clear, no other simple approximate designation can be suggested.

In 1909, Zerbe produced a machine—to be found illustrated in the earlier editions of Jane's "Aircraft"—in which each wing was composed of six tandem sections slightly overlapping, the trailing edge of one section overlying the leading edge of the section behind it. The sections were lenticular in end view, and the free passage between an adjacent pair was considerable. With the exception of the difference in the sectional form of the cross slats and a difference in the angle at which the wing as a whole was arranged, the system was substantially the same as found in the new Handley Page wing. We mention Zerbe's wing system especially, but we are well aware that hosts of other pioneers might be claimed to have forestalled Mr. Page.

The fact is, of course, that the virtue of Mr. Page's new wing lies not in the adoption of the slat principle, but in the form given to the section of the slats and of the passages between them and the overall assembly of the slats to make the complete wing. The general structure may be described as consisting of an ordinary wing of accepted section through which is formed a series of passages parallel with the leading edge. The form given to the passages has been a matter of prolonged, painstaking research, but the principles governing the final selection cannot be stated further than by saying that the gap between the walls of the passages decreases from the mouth to the exit.

So far, the results of laboratory tests are alone available in connection with fully slotted wings of the type shown in Fig. 1. These tests, we are assured, have established the fact that the slotted wing develops a very much greater lift per square foot of its surface than an ordinary wing, the increase being of the order of 200 to 300 per cent. Wings with but one slot near the leading edge are stated to show about 55 per cent more lift than similar wings without slots.

On Thursday of last week we witnessed at Cricklewood the ascent, flight and descent of two De H 9 two-seater machines, one with ordinary wings, the other with the ordinary wings modified with a slot at the leading edge, as shown in Fig. 2. The modified wing may be described as consisting of the original wing with its leading edge brought back from the point A to the point B, leaving the ends of the wing ribs exposed as at C, and with the outline of the section restored by means of a metal-covered "winglet" D attached to the rib ends. The winglet, it is to be understood, was definitely fixed

*Reprinted from *The Engineer* (London), Oct. 29, 1920, p. 42.

to the ribs; it could not, in the aeroplane examined, be turned about an axis so as to reduce or increase the section of the slot. The slotting was applied to both the upper and the lower wings.

On the ascent, during the flight, and on the descent of the two machines, it was perfectly obvious that the slotting of the wings had profoundly modified the aerodynamical qualities of the machine. The "slotted" machine rose at a sharper angle, climbed more quickly, alighted at a much slower speed, and pulled up in a considerably shorter distance than the other. Further, its pilot was able to fly it with its tail down—during horizontal flight—at an angle which would have "stalled" the other machine. It is stated that the machine can be flown horizontally with the center line of the fuselage inclined at nearly 45 degrees of the path of flight.

The demonstration last week suffered, from our point of view, by the fact that it was a popular one, to which all and sundry were invited. From a popular aspect it may be quite satisfactory to say that the new wing has a very much greater lift per square foot than an ordinary wing, that its lifting power is two to three or three to four times as great as that of the usual construction. From the technical and scientific standpoint, however, the statement cannot, we think, be accepted as it stands, nor do we believe that Messrs. Handley Page desire us to accept it without qualification.

It is not, we think, suggested that of two wings, one slotted, one plain, the slotted wing will develop two to four times as much lift as the plain wing when both wings are set with their chords at the same angle of incidence, and are moved at the same speed. Nothing that we have heard or seen implies such a claim, and until it is so advanced we shall prefer to look at the matter in a somewhat different way.

An ordinary wing set at the usual small angle of attack can be made to develop two or three times the normal lift by increasing the angle of attack, provided the wind-speed is maintained constant. The trouble is, however, that as the lift increases so does the drag or resistance. Hence, in an aeroplane with a strictly limited output of energy from the engine, the effort to increase the lift by increasing the angle of attack is defeated by the inability of the engine to maintain the speed against the increased drag. The speed falls, and, as a consequence, the lift decreases. The limiting condition is reached when the increase of lift derived from the increased angle of attack is just balanced by the decrease of lift produced by the enforced reduction of the speed. The machine in this condition is on the point of "stalling," and is in danger of falling or executing a tail slide. In the new Handley Page wing, we suggest, the construction is such that it is possible to fly with the tail of the machine down in an attitude quite beyond the reach of an ordinary machine. In this attitude the lift is increased, as it would be in the ordinary machine if the same attitude could be reached, but the drag is not increased or not increased to the same prohibitive extent, and is still within the ability of the engine to overcome. Looking at the sketch of the wing, it will, we think, be agreed that this result is what we should expect, and that as the angle of attack is increased it is possible even that up to a point the increase of lift may actually be accompanied by a decrease of drag. We suggest, then, that the curve of lift against angle of attack for the new wing will not be found to reveal anything much out of the usual, but that the curve of the drag at various angles of attack is distinctly out of the ordinary. It is a case, in short, not so much of increasing the lift at any given angle of attack, but rather of decreasing the drag.

Whatever may be the exact explanation, it seems certain that the new wing represents an important step in advance. It clearly permits the machine to which it is fitted to fly at very low speeds relatively to those hitherto regarded as the minimum, for it enables the pilot to place his machine in an attitude which permits him to work on a portion of the lift curve quite beyond the reach of the ordinary machine. In actual flight, of course, the problem is not to increase the total lift, but to maintain it, at all speeds, constantly equal to the weight of the machine. With the higher portion of the lift curve made available by the new wing, it is obvious that the total lift can be maintained by dropping the tail and reducing the speed. It is not to be supposed that passengers will relish traveling at a low speed with the cabin sloping downward toward the tail at angles up to 45 degrees. The journey will, as at present, be executed at high speeds with the fuselage horizontal—if necessary, by providing means for varying during flight the area of the slots in the wings. During descent or ascent, however, the slots will be opened with the result that slow landing speeds and ascents at sharp angles will be possible. The inclination of the fuselage to the path of descent or ascent will just about equal the inclination of the path to the ground surface, so that during the descent or ascent, the center line of the fuselage will remain substantially horizontal. Alternatively, the new wings may be built on to the machine at much larger angles than hitherto used. In this case the required lift will be obtained with wings of reduced area. The horse-power required to drive the machine at a given speed will be less, or with the same horse-power the lift may be increased and the extra lift be utilized to carry wings of greatly increased weight and strength.

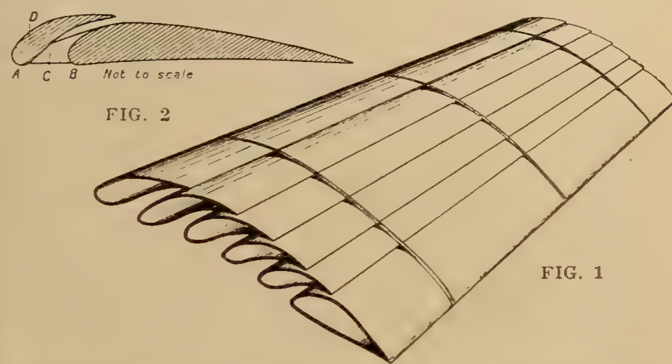


FIG. 2

FIG. 1

FIGS. 1 AND 2. DETAILS OF THE HANDLEY PAGE WING

INTERNATIONAL AIRSHIP NAVIGATION

Writing in *Revista Marittima* for June, 1920, Lieut. Gill Varoli-Piazza advocates the inauguration of airship lines radiating from Rome on account of its central position.

The routes proposed are Rome—Gibraltar—Fayal—New York: Rome—Gibralter—Paris—London: Rome—Alexandria—Cairo; Rome—Constantinople. The airships would be of two sizes, 100,000 and 50,000 cubic meters capacity, there being 8 of the former for the ocean lines and 9 of the latter for the Mediterranean lines. Allowing for an adverse wind of 5 m.s., New York would be made in 104 hours, Buenos Ayres in 156, London in 21, Cairo in 28, and Constantinople in 17. The cost of installation of the lines, including ships, landing stations, hangars, etc., is estimated at 145 million lire, and the cost of running and maintenance at 111 million per annum.—Abstracted by *The Technical Review.*

AIRCRAFT IN THUNDERSTORMS

Writing in *Illusrierte Flug-Welt*, Aug. 4, 1920, Major D. Carganico discusses the possibility of airplanes in flight being struck by lightning during a storm, basing his arguments on test flights under such circumstances.

He shows that no danger is to be expected if the machine is not in the direct line of a discharge, and even if it is, it is not likely from the nature and distribution of the conducting metal portion that danger due to fire will arise. Out of 30 cases where the machine was struck directly the writer maintains there were no evil effects, while in all known cases in Germany where a machine fell during a storm there was no evidence of scorching of parts or melting of metal.—Abstracted by *The Technical Review.*

Weather Conditions and Flight*

Climatological Factors Governing the Selections of Air Routes and Flying Fields

By C. Le Roy Meisinger

THERE is, it seems, a vagueness in the opinions of many people regarding the value of meteorology in the selection of air routes. One reads of "pathfinding" and of "charting" flights by which it is implied that a single journey or, at most, several journeys over a proposed course will afford sufficient data to designate that route as satisfactory or unsatisfactory for continued use. Such reasoning is unsound. It is obvious that the aerial medium is possessed of such a host of variable attributes, that the conditions which one finds today may not occur again in precisely the same combination for months or even years. Of what profit shall it be to measure the temperature, humidity, and other elements, in a single flight, unless it be that these data are to be used in the discussion of the flight itself, relative to the performance of the motor or instrumental equipment, the physiological reaction of the travelers, or in one or more of the several other problems that may take the form of special tests? If such observations are to be made, they should be made over a wide area, by numerous craft, and as nearly simultaneously as possible. The ocean of air is far from being a fixed thing. Perhaps the likening of the atmosphere to the aqueous ocean is a figure of speech which has been somewhat overdone, and has resulted in the popular conception of aerial currents as fixed as the Gulf Stream or the Japan Current. It is also possible that the pioneer work of Rotch and Palmer, *Charts of the Atmosphere for Aeronauts and Aviators*, which appeared in 1911, did not lay sufficient emphasis upon the pitfalls of too great reliance in averages. Our atmosphere is not made up of great permanent streams and currents, and even our conception of prevailing westerly winds aloft is sometimes shocked by the spectacle of cirrus clouds moving from the North, East, or South. Therefore, efforts to lay down definite airways without reference to the fundamental conditions which really determine desirable routes cannot prevent themselves being relegated to a position of slight importance. It would be unfair to assert that any carefully made scientific observation is of no value; but it is obvious that, in such matters as the selection of air routes, other factors than such observations must be considered before one can legitimately make generalizations upon so subtle a medium as the atmosphere.

THE SELECTION OF ROUTES

It is self-evident that the point of departure and the destination must determine the general direction of flight. But it is by no means axiomatic that the air route shall follow a straight line between these two points. Irregularities of the terrain, its physical characteristics, and the weather along the route must, in the last analysis, determine the course of the aviator, if he is to cover the distance with the greatest economy of time and fuel. In brief, it is the geography and the climate of the region between two stations which must determine the approximate route, but the weather at the time of flight must determine the details of the aviator's course.

While the fact is recognized that a single condition may not be representative of the weather over a given route, and also that mean conditions over the same route may differ greatly from the conditions of any particular day, it is believed, nevertheless, that the best basis for laying out a preliminary route between two points lies in the mean values of certain climatological and aerological factors.

Wind.—Perhaps the most important of all the weather elements to the aviator is the wind. It is necessary in commercial aviation to take advantage of any conditions which will aid in economy of time or fuel or will be conducive to greater safety. If, then, the "pathfinder" is to live up to his name, his first concern must be to determine the speed and direction of the prevailing winds over the proposed route. These winds should be determined, not at the surface alone, but to as great altitudes in the free-air as possible. Moreover, it is very likely that he will discover that certain elevations will, in the long run, be more favorable for flying in one direction, and that other levels will be more favorable for the return journey. Rouch and Gain[1] have shown how important such wind studies are in regard to flying in Northern Africa. The journey from Oran to Tunis, they find, should be made at an altitude of about 2,000 meters, because at this elevation a strong westerly wind prevails. The return journey, in the long run, will be made most profitably at an altitude less than half as great, because the westerly wind at that elevation is greatly diminished in force. Such prevailing winds should be determined from as long records as are available and should be worked out for small time units; seasonal averages would be valuable, but monthly means would undoubtedly be better. Not less valuable in this connection are the means of diurnal wind changes, both in speed and direction. In fact, each additional factor brings the conditions nearer to those which the aviator is likely to encounter in flight.

Digressions from the great circle[2] path between two points would be most helpful in cases of high winds and relatively slow-moving craft. Thus, a high-powered airplane flying at 110 miles per hour in a gentle wind would gain little, if any, by departing from the great circle. But a dirigible, on the other hand, moving at 60 miles per hour, might find it very much to its advantage to follow the general direction of wind flow if the wind speeds were quite high and if the curvature of the wind path were such as eventually to bring it near its destination. Thus, the gain to be made by departing from the great circle becomes smaller and smaller as the ratio of craft speed to wind speed becomes greater.

Cloudiness and fog.—The influence of the lower clouds and fog upon flying is very great. As a rule, it is essential to retain sight of the earth. When there are low clouds and fog, however, to keep in sight of the earth is obviously a hazardous proposition. The disadvantages of low flying when there is a cloud layer quite close to the ground have been set forth by Prof. B. Melville Jones,[3] as follows: 1. Strain to the pilot, owing to constant bumpiness, poor visibility, and proximity to the earth. 2. Danger of collision, occasioned by poor horizontal visibility. 3. Discomfort to pilot and passengers, since flying above clouds is exhilarating. 4. Choice of altitudes is limited, and therefore it is difficult to select advantageous flying levels. 5. Annoyance to people on the ground. 6. Danger in case of forced landings.

While Prof. Jones inclines to the view that overcloud flying has advantages over undercloud flying when the clouds are low, he does not hesitate to point out the danger and discomfort occasioned by having to ascend to great heights to clear clouds; moreover, it not infrequently happens that the cloud layer is thick, or that there are several layers. The danger of flying in clouds is great, not only because of the possibility of loss of sense of balance by the pilot, but because the clouds

*From the *Monthly Weather Review*, September, 1920, pp. 525-527.

[1]Les cartes des vents à l'usage des aéronautes. *Revue genérale des Sciences*, March 30, 1919, pp. 168-171.

[2]It is so customary to think of the earth's surface as it appears on a flat map that the fact often is lost sight of that the shortest distance between two points on a spherical surface is the arc of the great circle upon which the two points are located. This applies chiefly to long distances and is used by mariners; but it also applies in the case of long aerial routes.

[3]Flying over clouds in relation to commercial aeronautics, *Aeronautical Journal*, May, 1920, pp. 220-249.

may reach the ground without his knowledge, thus making a crash likely when attempting to land or descend to lower levels.[4] There is also the danger of being unable to find the landing field at the end of the flight and the difficulty of navigating without visible points on the earth. Whatever may be the advantages of overcloud flying, there is no escaping the fact that low clouds are a menace to the airman.

It is therefore necessary in the laying out of proposed aerial routes to consider carefully the frequency of low clouds and fog. Bodies of water, such as lakes, rivers, and the ocean, as well as cities and deserts, often contribute to the formation of fog and the production of low visibility.

Thunderstorms.—To the pilot of heavier-than-air craft no less than to the pilot of lighter-than-air craft, the thunderstorm is a formidable enemy and one to be studiously avoided. The few who have ever penetrated the interior of a thundercloud have suffered experiences which they would not care to repeat, if, indeed, they have come through alive. Dr. Charles F. Brooks has discussed several instances in which aviators have described their experiences in or near thunderstorms.[5]

Lighter-than-air craft are forced into the uncomfortable situation of having to land, or attempt to fly above, or around, the thundercloud, any or all of which may be extremely difficult. In the case of a dirigible balloon, it may be possible to fly around the storm as an airplane might do, and thus succeed in avoiding it. The alternative of landing in the face of the oncoming storm with its squall wind is not desirable because of the difficulty of handling the balloon on the ground. To attempt to fly over a towering thunderstorm may be entirely out of the question owing to the excessive altitude which would have to be attained, for great altitude necessitates unpleasant physiological effects and the loss of gas (through expansion) and ballast.

It is true that usually the thunderstorm is essentially a local phenomenon, which may attend the passage of the windshift line in a LOW or may be formed locally by strong convection. Thus, the chances of encountering thunderstorms during a given trip are very much dependent upon current general conditions. But the frequency of occurrence of thunderstorms along a given route is a thing that it is vitally important to know. For one may discover that in certain months in a given region the thunderstorm frequency is so great as really to endanger the maintenance of schedules. An aircraft corporation may discover by such statistics that their craft will be placed in great danger by maintaining routes through regions of great thunderstorm frequency. The wisest course in those cases might be to modify the schedule during those times, to select new routes, or to discontinue service in that region temporarily. Again, this knowledge can give some clue to the possibility of profitably modifying the administrative activities of the corporation, such as shifting the personnel of flying fields, distributing equipment, extra parts and supplies. All of these factors will have their reflection in direct financial returns. A blind indifference to the statistics of climate over air routes is, therefore, a narrow business policy, and that corporation which manifests this indifference is the one which, no matter how skilled its pilots, will find its dividends dwindling because of loss of equipment through accidents and consequent loss of popularity with the public.

Temperature.—The knowledge of mean temperatures over routes is perhaps the least important of the weather factors. It is true that temperature has a profound influence upon the maintenance of schedules in extreme weather. But with the improvement of aircraft engines so that they function at extremely low temperatures, and with the electrical heating of the cabins of passenger-carrying planes and dirigibles, the influence of the temperature factor is appreciably lessened. Information regarding average vertical distribution of temperature and of the diurnal change of this distribution is helpful. Unfortunately such data are somewhat limited, but the Aerological Division of the Weather Bureau is conducting a study of a great number of kite flights which will probably supply to a large degree this need. The knowledge of mean vertical temperature distribution is not as important in the preliminary laying out of air routes as in the discussion of the current data supplied to the aviator just before he ascends.

Humidity and precipitation.—These elements are not of great importance at the outset, and they are so interwoven that their value depends chiefly upon the interpretative ability of the consulting meteorologist at the flying field.

THE SELECTION OF FLYING FIELDS

The problem confronting the person whose duty it is to select a flying field is not an easy one; or, at least, it is one that cannot be rightly solved by a mere consideration of the civil or military requirements. Today, with the multitude of flying routes being established, it sooner or later becomes the problem of the commercial clubs or chambers of commerce in most large cities to determine a landing field in the immediate vicinity. These fields have a great commercial value to the city. It is not denied that many of the local aspects, such as the availability of property, accessibility, etc., each peculiar to a given locality, rightfully have a foremost place in the consideration. But the meteorological aspect can not be neglected, for it is conceivable that, in spite of a hundred desirable features of a landing field, there may be certain characteristics which, from a meteorological standpoint, will render it utterly unfit for the purpose. Again assuming the climatic features to be favorable, the field itself must be so laid out that it will serve most efficiently. That is to say, for instance, that the long axis of the field, if it be small and rectangular as many are, should lie in the direction of the prevailing wind at the place, because it is necessary that planes land heading into the wind and that they also rise in a headwind. The buildings should be so oriented and distributed as to interfere the least with landing or rising planes, and where the eddies and gusts they cause will not interfere with craft flying low over the field.

A very striking example of the consequences of neglecting the meteorological aspects is given by Rouch.[6] During the war, the British desired to establish a training field for aviators for bombing instruction, and a commission was appointed for the purpose of determining the location. The shore of Loch Doon, in Ayrshire, was chosen. After the work of establishing the field was well along, the hangars were being built, a railroad was contracted for, and other expensive arrangements had been made, it was discovered that the neighboring hills gave rise to eddies and squalls which absolutely prevented safe flying at that place. The field was abandoned with a loss to the Government of upwards of $2,000,000. In conclusion, Rouch says, "The installation of some instruments and the consultation of some tables of figures would have permitted 12 million francs to be saved. In that circumstance, sadly writes the *Times* (London), the authorities did not perform their duty." It is unnecessary to emphasize the import of this example.

The Air Service recognizes the tremendous importance of the climatological considerations in the selection of flying fields.[7] To quote from the circular which discusses this question:

"The number of flying days to be expected in a year or in

[4]The writer had such an experience in a free balloon. Having ascended into a rather low layer of clouds and having lost all sense of direction, the party was surprised to discover several hours later that the trail rope of the balloon was dragging on the ground. The low clouds had actually reached the surface. For full account, see "A free balloon flight in the northeast quadrant of an intense cyclone," *Monthly Weather Review*, April, 1919, 47 : 233-235.

[5]The effect of wind and other weather conditions on the flight of airplanes. *Monthly Weather Review*, August, 1919, pp. 523-532. See also Meisinger, C. LeRoy: A balloon race from Fort Omaha through thunderstorms, idem., pp. 533-534.

[6]Préparation météorologique des voyages aériens. Paris, 1920, pp. 53-54.

[7]Meteorology and Aeronautics. *Air Service Information Circular*, May 12, 1920, Vol. 1, No. 77.

any month may be fairly well determined from a study of the climatic factors. . . . It is also possible from this study to arrive at a fairly definite conclusion as to the accessibility of the field by aerial routes for different types of aircraft. In other words, one may determine the sort of aerial harbor, ease of entrance, exit, and other things considered which aircraft would find at a given field. . . . The prevailing wind and storm directions largely determine the layout of a field. The number of days to be expected when the wind speed is too high for the operation of aircraft may be closely determined. Also the number of days with excessive precipitation, with fog or storm to be expected, may be closely approximated."

The weather factors to be taken into consideration are quite the same as those which may determine aerial routes. Precipitation comes in for greater consideration in the case of landing fields. A plane can not land or take-off readily on a muddy field, and a snow cover demands the greatest attention.[8] As the Air Service circular points out, topography and wind are inseparably bound together in relation to aeronautics. The effect of wind blowing over a rough terrain is to produce rugh air in which to fly. Landing fields in a hilly region are especially apt to be dangerous; and the proximity of trees and high buildings is likely to cause roughness extending to a height three or four times as great as the object. This is dangerous to a plane slowing down for a landing or for slow-flying planes.

CONCLUSION

An effort has been made to present the vital importance of meteorological studies in connection with the establishment of aerial routes and the layout of flying fields. The argument does not pretend to overstress the use of averages in connection with such work, but it does attempt to emphasize their importance in the preliminary work. Meteorology is the mainstay of aviation regardless of the confidence of the aviator in his motor and its ability to carry him safely over all obstacles. The dirigible has inspired us with a confidence in its future as a commercial transport; the aerial mail has definitely stamped the airplane as a reliable means of rapid transportation of mail, baggage, and passengers. Great aerial corporations are being organized. They are commercial enterprises, highly capitalized and founded for the purpose of paying dividends to their stockholders. Dividends depend upon the skillful management of the assets of the company, the reduction of the expense of maintenance, the extension of routes into the most profitable places, the acquisition of the public confidence. Every accident is detrimental to the cause of aviation, not alone because of the direct financial loss, but because it weakens the public confidence. The record of the Aerial Mail Service shows that the weather is responsible for the greatest number of accidents and forced landings.[9] Many of these could be avoided by giving the weather its due consideration. Here is one of the places where the consulting meteorologist is urgently needed.

THE PREDICTING OF MINIMUM TEMPERATURES

THE Journal of the Washington Academy of Sciences for July 19, 1920, contains an account of a paper presented by Mr. J. Warren Smith before the academy.

This paper was a discussion of the relation between the relative humidity in the late afternoon and the variation of the minimum temperature during the coming night from the afternoon dewpoint temperature, when radiation conditions prevail. The study shows that there is a well-defined relation which can be expressed by the curve for a parabola. This curve can be constructed by the "star point" method of curve fitting instead of by the more tedious well-known least square method.

The equation used is written $v = x + by + cz$ in which v is the variation of the minimum temperature from the evening dewpoint; b is the evening relative humidity, and c is the square of the relative humidity. x, y and z are the three unknowns, which are evaluated from three normal equations which are readily written by the star point method after the data have been properly charted. The results are remarkably accurate. The studies show that the minimum temperature can be closely predicted in the orchard at a considerable distance from the observing station; that the hygrometric observations made at noon may be used quite as well in some instances as those made in the evening, and that the equation will sometimes apply as well to cloudy as to clear nights.

By using the depression of the dewpoint instead of the relative humidity in correlating with the variation of the minimum temperature from the dewpoint there is, in some instances, an even closer relation shown. In this case a straight line from the equation $v = x + yd$ fits the data fully 89 per cent of the time. In this equation d is the depression of the dewpoint, v is the variation of the minimum from the dewpoint, and x and y the two unknowns.

CHARCOAL METHOD OF GASOLINE RECOVERY

IN the September number of *Chemical Age* (New York) a discussion of the charcoal method of gasoline recovery is presented by G. A. Burrell and associates. It will be recalled that about three hundred million gallons of natural gas gasoline will be produced during this year by compression, refrigeration, and absorption methods applicable to casing head gasoline with oil absorption in the case of so-called dry gasoline. Various combinations of these methods have been employed and occasionally difficulty is experienced in marketing the product from oil absorption or compression plants because of the high evaporation losses. The charcoal process consists in bringing the gasoline in contact with activated charcoal which retains the recoverable gasoline vapors and allows the gas thus stripped to return to the distribution lines. When the charcoal becomes saturated the gasoline is allowed to come in contact with a fresh supply and the vapors are recovered from the charcoal by distillation with superheated steam. The vapors are condensed, blended and then stored preparatory to marketing. It is claimed that not only is the charcoal plant less costly to instal but that it is cheaper to operate and it produces gasoline of greater quantity and better quality than do the compression or oil absorption plants. The gravity and vapor tension of this recovered gasoline is less than that made from the same gas by either of the older processes. This is due in part to the conditions under which condensation takes place, being under atmospheric pressure only. The method by which condensation is carried on is also a factor, the charcoal process being a bath process where consecutive distillations of a series of absorbers take place instead of continuous distillations in a still. In this manner the lighter vapors are driven off first and the application of the blending naphtha to the material that actually needs blending is allowed. Thus any wild vapors in the charcoal are driven out first by the lowest temperature and do not come in contact with the gasoline which is to be sold. It is also claimed that selective absorption takes place giving clear-cut fractionation, so that the so-called wild vapors are eliminated in the absorption itself. 93 per cent of the charcoal absorption gasoline is recondensed after the standard Bureau of Mines distillation which is nearly 50 per cent higher than is the case with materials recovered by other methods.

The yield is not sacrificed at the expense of quality and a comparison between an oil absorption plant and a charcoal plant operating on gas poor in vapors show that the oil plant averaged about 125 gallons per million cubic feet of gas and had a weathering loss of 20 to 30 gallons before shipment.

[8]A note in *Aeronautics,* March 18, 1920, p. 230, tells of the addition of ski attachments to the plane where landings have to be made on snow. One of the great difficulties of landing on snow, as on water, is to tell how high the airplane is above the surface, for, with a perfectly smooth snow cover, it is difficult to judge distance; and even to know when the skis are actually in contact with the snow.

[9]Effect of weather on the Aerial Mail Service. *Monthly Weather Review,* June, 1920, pp. 335-336.

Submarine Steam Whistles*

Producing Sound Underwater by the Condensation of Steam

By Gerald Stoney, F.R.S., aud Telford Petrie, M.Sc.

THE great war has undoubtedly increased our knowledge of practical acoustics. Problems affecting the location and detection of sound have had to be met and solved in the shortest possible time. The foundations of the subject, more especially on the theoretical side, had been well laid by Helmholtz, Poynting and Thomson, Lamb, and particularly Lord Rayleigh; but it was left to modern physicists such as Perrin and Walser in France and the two Braggs in England to bring listening gear, for both land and sea conditions, to a pitch of perfection that had not been previously reached or apparently been required. The sounds listened to were mostly those made by the enemy; but another phase of the subject was introduced when the detection of submerged bodies, such as submarines, was first considered. It was then thought necessary to produce a reliable and distinctive note or sound under water to be applied for this purpose. This was one of the problems to which the Lancashire Anti-Submarine Committee devoted itself; and the authors were deputed to investigate the possibilities of utilizing steam for the production of such a note.

The production of musical notes under water does not in itself seem to have received much attention in the past. Where such attempts have been made they have been devised for ulterior purposes, such as the determination of the velocity of sound in liquids. In 1826 Colladon and Sturm[1] carried out their famous experiments to find the velocity of sound in water, and used a bell 70 cm. high and slightly less in diameter. This was immersed 1 m. in the Lake of Geneva and struck with a hammer. The sound was picked up 13,487 m. (9.6 nautical miles) away. In 1847 Wertheim used organ pipes for the same purpose, which were sounded by forcing a current of water through them.[2] Varying presures of this water gave varying harmonies; considerable difficulty appeared in proportioning the pipes to sound under water. In 1853 Savart[3] produced sounds by the efflux of water from tubes, a method which was used by T. Martini[4] in 1884 to determine the velocity of sound in various liquids. The tube is stopped at the bottom by a diaphragm with a small hole in it, but the note appears in the column of water in the tube and the tube does not appear to have been completely submerged itself.

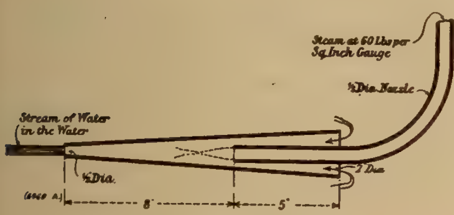


FIG. 1

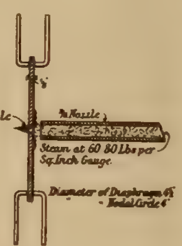


FIG. 2

With regard to the siren, Poynting and Thomson say "as a matter of curiosity we must mention the fact that the siren sounds under water if entirely immersed and driven by a stream of water"[5]—but this method did not fall within the scope of the present research, nor did the use of bells which have been developed for submarine telegraphy.

For their laboratory experiments a steam pipe, $1\frac{1}{4}$ inches internal diameter, was led vertically into a well below the condenser water measuring tanks in the authors' laboratory. This well could be flooded to a depth of 16 feet or emptied at will. The investigation started in attempts to obtain a musical note by the simple expedient of blowing steam down into the water through the central hole of a thin diaphragm which closed the outer end of a short length of the $1\frac{1}{4}$-inch steam pipe. These attempts failed even when the short length was insulated from the main steam pipe by a length of rubber hose.

Another idea was suggested by Wertheim's method already referred to; but attempts to blow organ pipes under water by steam instead of by a current of water also failed. In connection with this, it is perhaps worth recording that by taking advantage of the partial vacuum caused by the condensing steam, and fitting a funnel to the nozzle long enough to allow all the steam to condense, as shown in Fig. 1, the authors subsequently succeeded in blowing an extemporized organ pipe under water with the pure jet of water that was obtained.

The short length of steam pipe used in the first experiments was then replaced by a receiver consisting of a cast-iron pipe 4 inch internal diameter and 2 feet 10 inches long. The $1\frac{1}{4}$-inch steam pipe led into the top of this receiver and the lower end was closed by a series of diaphragms with central holes of various sizes. The whole was submerged to a depth of 6 feet. The results could hardly be called promising, but notes of between 100 and 150 periods were occasionally obtained. The frequency was measured by comparing the note in the air, as it came through the surface, with a tuning fork by ear. This method, which was only required for comparative purposes, was used throughout in the laboratory. From the fact that the notes sounded like a cow mooing, the apparatus was colloquially referred to as the "cow."

The steam pressures, as measured on a calibrated Bourdon pressure gage near the stop valve, were so low that it was doubtful whether there was not a considerable quantity of water on the inside of the diaphragm. To test the effect of a water-borne diaphragm, another arrangement was tried. This simply consisted in playing a jet of condensing steam from a nozzle on to a diaphragm under water. A soft but distinct note of about 408 periods was obtained. In order to clear the steam as soon as it had impinged upon the diaphragm, the apparatus was then arranged so that a small hole in the center of a vertical diaphragm allowed the condensing steam to impinge on its edges and escape on the far side. The note was distinct, and better than the previous one, but still too soft.

In all the methods attempted so far, the diaphragm had been clamped round its edges. The next step was taken to ascertain what the effect would be if the diaphragm were free to vibrate of itself, without transmitting its motion to the supporting apparatus. A convenient way of obtaining this was suggested by the well-known Chladni figures. In one of these a circular plate is supported on pointed corks under a nodal line and vibrated by rubbing a cord up and down against the side of a hole in the center of the plate. Poynting and Thomson give the positions of such nodal circles when one, two or three nodes are present. For convenience in clamping, the largest of the three node circles was chosen, namely, 0.894 D, and the diaphragm was supported on opposed knife edges at two points only on such a circle. The result was encouraging. A clear musical note about 600 frequency was obtained without difficulty when the conditions were adjusted as shown in Fig. 2. The repetition of this experiment in a larger tank appeared to establish the fact that the note was produced in

*Reprinted from *Engineering* (London), Oct. 29, 1920, pp. 561-563.
[1] "Annales de Chimie et de Physique," Series 2, Vol. XXXVI, 1827.
[2] *Ibid.*, Series 3, Vol. XXIII, 1848.
[3] *Comptes Rendus*, August, 1853.
[4] "Atti del Reala Instituto," Veneto, Series 6, Vol. IV appendix.
[5] "Text-book of Physics," Sound, 1899 Ed., bottom of page 37.

the water, and not, as had hitherto seemed to be the case, in the steam or by the mechanical vibration of the apparatus as a whole.

A number of experiments were then made with this form of apparatus, and the following points were brought out:

(*a*) A circular nozzle with parallel sides gave the most suitable form of jet of condensing steam.

(*b*) While notes could be obtained with various ratios of the diameter of this nozzle to the diameter of the central hole in the disc, a proportion of two to one was found to be very suitable.

(*c*) The distance between the end of the nozzle and the disc was an important factor, other conditions remaining the same.

(*d*) The proportions and material of the disc did not appear to have any controlling effect on the frequency of the note. This led to the unexpected conclusion that the note was not being produced by the vibration of the diaphragm, as had hitherto been supposed, but in some way by the condensing steam itself.

With the experience gained by the laboratory work already described, an experimental apparatus was designed. In this apparatus gear means were provided for adjusting the distance between the nozzle and the disc from above the water-level whilst the steam was on. Arrangements were made for carrying diaphragms of different sizes or discs of varying thicknesses, and also for changing the diameter of the nozzle. As a result of the laboratory work carried out with this apparatus, the following conclusions were reached

(*e*) To get a pure note the disc should be clamped on a nodal circle. This prevents the vibration from being transmitted to the remainder of the apparatus, to any appreciable extent. Subsequent work has shown that this point is not so important with small models (e. g., ¼ inch or ⅛ inch diameter nozzles), but that the greater the energy produced the more necessary it is to take this precaution.

(*f*) The note, for any given pressure (and water temperature), was not continuous as the disc was run in toward the nozzle. A high note about 800 frequency was obtained at a certain point when the distance between the two was great, and was usually held as the disc was brought in, until a second point was reached where the note changed suddenly to one of a much lower frequency (about 200). It was occasionally possible to obtain a third note, of about 100 frequency, but all three notes were not always present with similar conditions.

(*g*) The size of the nozzle, and therefore the quantity of steam passing, affected the pitch of the notes. The smaller the nozzle, the higher the note, other things being equal.

(*h*) The pressure of the steam for any given size of nozzle correspondingly affected the frequency of the notes. The lower the pressure, the higher the note.

(*i*) As far as could be checked in the confined space of the laboratory, the maximum intensity of the note appeared on the steam or nozzle side of the disk.

The apparatus was then fitted to H.M.S.T. Leonora, stationed at the Admiralty Experimental Station, Shandon, N. B., and the following trials were carried out: First of all a 4½-inch disc ¼ inch thick and ½ inch nozzle, was tried out at 300 yards, at three pressures corresponding to 105 pounds, 75 pounds and 30 pounds per square inch on the gauge on deck. An independent observer listened from the shore with a general service hydrophone (G.S.H.). All notes were loud, the best one being at the medium steam pressure. The distance was then increased to two nautical miles. (Garelochhead to Shandon.) The listener was stationed in a dinghy off Shandon, and reported no appreciable diminution in sound at that range. Both the top and bottom notes at each pressure were heard. The boat was turned broadside on for this test, but the note was also heard while the boat was steaming away from the listener at three knots.

A ½-inch nozzle was then tried with a ¼-inch hole, in a 11¾-inch diameter (½ inch thick) diaphragm. It was soon established that the larger disk gave better results. The note was obtained over a longer range of pressures and was more piercing. The best note of all was with anywhere between 60 pounds and 75 pounds per square inch on the gage with the diaphragm ⅜ inch away from the end of the nozzle. These results were then compared with a diaphragm 11¾ inch diameter, ½ inch thick, with a ⅜-inch central hole, using a ¾-inch diameter steam nozzle. The note was deeper and coarser, and the top note not so pure at short range. There seemed to be no advantage gained to make up for the extra steam used. (More than double the amount being required.)

As a result of these trials the following proportions were adopted for the subsequent work carried out with this form of apparatus. A steel diaphragm, 11¾ inch diameter and ½ inch thick, was clamped in two places on a nodal circle of 10½ inch diameter. It had a central hole of ¼ inch diameter which was tapped with a fine thread. The nozzle used was ½ inch diameter with parallel sides. This apparatus gave a powerful note with a steam pressure of from 60 pounds to 75 pounds per square inch on the gauge on deck when the distance between the diaphragm and the end of the nozzle was ⅜ inch. At first the nozzle was arranged pointing inward toward the ship. It was next pointed forward, and the ship steamed round in a circle 600 yards away. The note was heard all the time, even when the apparatus was on the other side of the ship, but was loudest when the ship was steering away from the listener. This corroborated the conclusion arrived at in the laboratory.

In further tests which were carried out in the Gareloch, the listener was stationed in a dinghy in four fathoms of water at the mouth of the loch, and the apparatus was tried out when the ship was two nautical miles away, i. e., off Shandon, and four nautical miles away, i. e., the full length of the loch; no appreciable diminution in sound was perceptible between half-way and the full distance. The medium pressure again gave the best results, and the note came through the noise of a motor launch 100 yards away from the listener. Up to the present the weather had been fine and the sea calm. The apparatus was next tried out in the Clyde in rough water. An independent observer picked up the note three nautical miles away, listening from a moving motor launch with a No. 2 "Lancashire Fish."

The longest range attempted was 11 nautical miles, when Lieutenant Dix, R.N.V.R., and Mr. Dobie, of Messrs. Cammell Laird, using a general service hydrophone, heard the note from a stationary motor launch so distinctly that the sound came out of the receiver as it lay on the cabin table. The sea was calm and the minimum depth of water between points was 16 fathoms. In this trial the ship was laying off Wemyss Point in the Clyde and the motor launch was just outside Little Cumbrae. In a test under bad weather conditions the ship was left alongside Gourock Pier and Mr. Redfern, a member of the Lancashire Anti-Submarine Committee, sailed toward Gareloch, listening with a No. 2 "Lancashire Fish." The conditions were bad, rough sea and shoals up to 1½ fathoms between. The note was heard distinctly all the time until the corner was turned into Gareloch. At two nautical miles Mr. Redfern found that he could compensate the note and gave the correct direction of Gourock from his cabin. The motor launch steamed out again and, laying off Helensborough, 4 nautical miles away, picked up the note again on a general service hydrophone.

The results of these sea trials pointed to the development of a convenient and cheap apparatus for producing a loud note under water, of considerable penetrating power. It was also found that a bar may be used instead of a circular diaphragm. Such a bar is conveniently damped and supported by a knife-edge at a nodal distance from the free end, the values of which may be obtained from Poynting and Thomson's "Sound," 1899, page 127. As used in the apparatus this distance is 0.226 L from the free end; but laboratory experiments have shown that other values would serve equally

well. The hole should be placed at the point of maximum amplitude.

An opportunity occurred to carry out some further experiments at the Admiralty Experimental Station at Shandon. No long-range work was possible; but work in the Gareloch made it possible, for the first time, to measure the frequency of the note used in the previous long-distance trial. The note was listened to at a distance of 1 nautical mile, and the frequency measured. The average frequency of the dominant note was found to be 880 periods per second, with similar conditions of apparatus and steam pressure as were used in the long-distance trial. There appeared to be two sources of sound, which tend to confuse the listening from the ship (or near to); one from the steam jet, which is dominant, and one from the vibration of the apparatus. By the use of a swinging bar it was found that the former note penetrates, but that the vibration of the apparatus does not carry more than 1 mile. This point was determined by first holding the bar with the hole in the center of the steam, then with approximately half the hole across the steam, and finally with the bar obstructing the steam between the hole and the edge. All three settings gave piercing notes when listened to on deck, but only the first two appeared to reach the listening station, just over one mile away.

The disk was made of mild steel, whereas the bar was of best brass. This latter material, after only 3 hours' running, showed marked signs of pitting, due to the force with which the steam bubbles collapsed; and it is obvious that the obstruction that carries the hole should be of hard material to withstand the wear of constant use. The mild steel disk

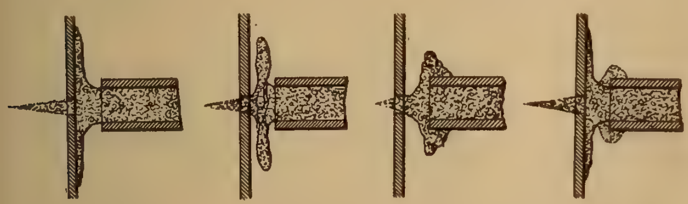


FIG. 3 FIG. 4 FIG. 5 FIG. 6

had been used throughout the sea trials, and showed only the slightest signs of wear.

During the war, the research had been carried on with the object of achieving results; and, beyond noting points as they occurred, nothing was done to investigate the cause of a phenomenon that appeared to be new. The authors have since taken the opportunity of analyzing the production of such a note under water by means of a condensing steam jet, under the auspices of the Manchester Municipal College of Technology.

The work that had already been done pointed so clearly to the production of the note in some way by the action of the condensing steam, rather than by the vibrations of the diaphragm or of the bar, that an attempt was made to ascertain the movements of the jet while a note was being produced. For this purpose a laboratory model was used, which consisted of a straight-through nozzle, ¼ inch in diameter, and a number of mild steel disks 4½ inches in diameter supported in one point only on a nodal circle 0.894 D., by an overhanging adjustable arm. A number of brass bars, 1 inch wide and 5 inches long, were also available. It was with these bars that various positions of the damping node had been tried out. The apparatus was placed in the center of a tank, 26 inches square by 22 inches deep, which could be filled with clear water and emptied at will. The incoming feed-pipe delivered the water near the bottom and an overflow drew it off from the surface. This made it possible for the water to be changed while the apparatus was running, so as to regulate the temperature and counteract the heating effect of the condensed steam. The steam pressure was read on a calibrated Bourdon gage placed just above the tank, the steam supply being adjusted by hand on a stop valve.

Two 3½-inch diameter tubes with watertight glass windows were projected into the tank, one on each side of the nozzle, and a parallel beam of light was passed through. In this way the action of the steam could be watched under water. A stroboscope was used, consisting of a revolving disk with six slots, the width of which could be adjusted, driven by a controllable electric motor whose relative speed was checked by a tacheometer. The arrangement made it possible for the stroboscope to be run at any speed up to 1,200 r.p.m., or 120 periods per second. Various combinations were found possible. A satisfactory result was obtained when a bar was placed ⅛ inch away from the nozzle. With a steam pressure on the gage of 45 pounds per square inch and an average temperature of the water of 63 deg. F., a note was produced whose frequency, compared with a tuning fork in the air, was 420. When the stroboscope was run at a speed of 1,040 r.p.m., corresponding to a frequency of 104, the movements of the condensing steam were clearly visible.

The steam is spread out like a mushroom by the flat surface, while the hotter central core escapes through the hole. The appearance is something like Fig. 3. The mushroom travels backward away from the flat surface in the form of a ring or disk of condensing bubbles. The effect produced may appear like Fig. 4. This ring gradually collapses on and around the end of the nozzle, as in Fig. 5. The onward rush of steam from the nozzle forms another mushroom as the previous one is disappearing, and the process repeats itself (Fig. 6). In both 4 and 5 less steam comes through the hole to the other side of the flat surface. The flat surface acts as a condenser, and possibly as a sounding board, since the thicker it is, the sharper and clearer the note appears to be, within limits. A thin ring of steam nearest to the surface and farthest away from the nozzle condenses first, and allows the water to rush in from all sides. The result is that, momentarily, the flow of steam is checked, and the steam mushroom is forced backward to collapse more gradually against the nozzle. The jet of steam through the hole shortens simultaneously with the retrogression of the mushroom ring. The collapse of this ringed wall automatically relieves the steam pressure, which rushes forward again out of the nozzle, and the cycle recommences. The musical note is apparently produced by a series of pulses or blows rather than by vibration or oscillation. Practically, it amounts to ringing water on water.

It is interesting to note how this theory accounts for the points observed and described in the first part of this paper.

The pitch is known to be higher: (*a*) The smaller the nozzle or (*b*) the lower the pressure, *i.e.*, in both cases, the less the volume of steam flowing per second; (*c*) the farther away the surface is from the nozzle. The less the volume of steam flowing, the smaller and more rapidly formed would be the steam bubbles and the mushroom heads. The periodicity of the note would therefore be higher. The longer the steam jet between the nozzle and the plate, the smaller in diameter it becomes before it impinges round the edge of the hole, and consequently the smaller the mushroom, as before. It is doubtful whether the ring travels back as far as the nozzle when producing these high notes; it probably collapses instead on the jet.

As a check on these conclusions, the stroboscope was removed, and only sufficient steam admitted to form a thin film against the flat surface. No note, of course, was formed, but the repulsion of this film backward could be clearly seen. Osborne Reynolds once explained the singing of a kettle on the hob in a paper read before Section A of the British Association, at Oxford in 1894.[6] He pointed out that at about 10 deg. F. below boiling-point bubbles of steam are formed at the bottom of the kettle, which collapse suddenly with a

[6]Experiments showing the boiling of water in an open tube at ordinary temperatures. Reprinted in *Scientific Papers*, 1901, Vol. II, p. 578 *et seq.*

sharp click when their ascension brings the steam into contact with the colder water above. This is apparently what is happening in the phenomenon just described. The flat surface, be it a diaphragm or a bar, takes the place of the colder water in the kettle, and, being a good conductor of heat and being surrounded by cold water, does not get sufficiently hot to prevent the condensation from being continuous. It may perhaps be noted that if the temperature of the water in the tank is allowed to get hotter the pitch of the note gradually rises. The effect of the central hole appears to be twofold; it allows the hotter portion of the jet to escape and so facilitates the immediate action of the condenser; and by relieving the pressure it prevents the steam from piling up between the nozzle and the plate and so defeating the mushroom effect.

It will be recalled that the authors found a bar made of best brass to be badly pitted or eroded after only 3 hours running in the sea. This points to comparatively large instantaneous pressures being set up by the collapse of the steam bubbles against the flat surface. In a paper read by the Hon. Sir Charles Parsons and Stanley S. Cook, on "Investigations into the Causes of Corrosion or Erosion of Propellers," before the Institution of Naval Architects on April 10, 1919,[7] a description is given of some water-siren experiments made by A. Q. Carnegie. When the fixed disk was made of soft cast brass, it eroded too badly for use in the siren after 10 minutes' running under a water pressure of 70 pounds per square inch. This effect is attributed to the momentum of each interrupted jet, causing momentarily a vacuous space to form behind it. The return action by concentration finally produces high velocities and pressures in a small volume of the fluid, giving rise—when the nucleus of pressure, or point at which collapse takes place, is located on the metal—to excessive water-hammering over a small area. In Appendix II of the same paper, Cook supposes that a rigid inner boundary to the fluid enclosing a vacuous space is suddenly removed; and he obtains an expression for the instantaneous pressure thus produced. His calculations and conclusions were confirmed by the late Lord Rayleigh in a paper to the Royal Society in August, 1917. Cook shows that the pressure on impact is independent of the size of spherical vortex cavities, and is only a function of the ratio of the initial to the final radii; so that very small cavities may cause erosion. For instance, when a spherical vortex cavity in the sea closes upon a central nucleus of one-tenth of the diameter of the original cavity, the blow upon this nucleus may reach 24.2 tons per square inch. If the diameter of the nucleus is one-hundredth of the diameter of the original cavity, the pressure may reach 765 tons per square inch.

Such instantaneous pressures, if present in the collapsing of steam bubbles against a flat surface, would account for the erosion noted in the brass bar. They would also point to the value of such a means of producing sound under water when long penetration is required, for energy is directly imparted to the surrounding water without the necessity of resonators or of any heavy mechanical apparatus such as is used in present submarine signaling gears.

In conclusion, the authors desire to express their indebtedness to the Admiralty for permission to refer to work which was carried out under their auspices, and also to thank the authorities of the Manchester Municipal College of Technology for enabling them to investigate the cause of what appears to be a new method of producing sounds under water.

[7]There is a reprint of this paper in *Engineering*, April 18, 1919, p. 515.

RESILIENT STEEL GEARS

A BRITISH company has brought out a type of gears called resilient steel gears which are noiseless and have special features. The teeth of these noiseless resilient gear wheels are built up of a series of steel laminae placd in planes that intersect the axis of the wheel. These laminae are arranged at such an angle to the face of the teeth that they close slightly on one another when the teeth engage; the result is an evenly distributed pressure instead of the hard metallic blow that takes place with solid gears, and even at high speeds and under heavy loads a slight buzzing is all that can be noticed. The laminae are held in position, each independently of the remainder, by clamping plates, annular projections on which fit into corresponding recesses in the lateral extremities of the laminae. In wide wheels one or more center pieces are inserted, and screwed bolts passing through the clamping plates, laminae, and center plates (when employed) fasten the whole together. Between the underside of the laminae and the boss there is a receptacle for lubricant, which is filled in through holes in the clamping plates, and owing to centrifugal force and the slight pumping action, is forced radially outwards between the laminae, furnishing efficient lubrication for the whole width of the teeth.

As compared with raw hide and paper pinions, it is claimed that these gears, owing to the strength and hardness of steel, will carry a greater load, or a given load on a narrower width, and that, being indifferent to wide variations in temperature and impervious to oil, water, or steam, they have a longer life. The resiliency of the working faces of the teeth corrects any small irregularities occurring in these surfaces. A pinion now in course of manufacture for a colliery in the North is intended to transmit 750 horse-power at 295 revolutions per minute. Its width is 13½ inches and its overall diameter 26 inches and there are 24 teeth, 3-inch pitch. The weight is about ¾ ton. The flanges and boss are of cast steel, and the working faces of the teeth of 40-ton forged steel. The gear will hold enough lubricant to last two or three months.

EYESTRAIN IN CINEMAS

AN interim report of the representative joint committee appointed by the Illuminating Engineering Society to inquire into eyestrain in cinemas forms part of the contents of a "special cinema issue" of the *Illuminating Engineer* (32 Victoria Street, S.W.1). The inquiry originated in a request made to the Illuminating Engineering Society by the London County Council for information in regard to the possible causes of eyestrain in cinemas, and the best mode of removing them. Attention was particularly drawn to "the question of the strain to the eyes caused by the proximity of seats to the screen at cinematograph halls, and of some means of lessening the ill-effects referred to." The committee received the coöperation of the Council of British Ophthalmologists and the Physiological Society in dealing with this difficult problem, and seem to have taken great pains to make their investigation as complete as possible. They recommend (1) That the angle of elevation, subtended at the eye of any person seated in the front row, by the length of the vertical line dropped from the center of the top edge of the picture to the horizontal plane passing through the observer's eye, shall not exceed 35°, the height of the eye above the floor-level being assumed to be 3 ft. 6 in.; (2) That provided recommendation No. 1 is complied with, the angle between the vertical plane containing the upper edge of the picture, and the vertical plane containing the observer's eye, and the remote end of the upper edge of the picture should not be less than 25°. They do not anticipate that any supplementary report which they may make will necessitate modification of the above recommendations. The representatives of the cinema industry, while approving of recommendation No. 1, draw attention to the absence of definite evidence of serious injury by eyestrain. In view of this fact, they are of the opinion that where application of this condition to existing halls would entail serious financial hardship there is no justification for its imposition. They are further of opinion that the normal development of the cinema theater will rapidly remove all causes of possible discomfort.—From the *Journal of the Royal Society of Arts*, Sept. 3, 1920.

Science and National Progress

Edited by a Committee of the National Research Council

Dr. Vernon Kellogg, Chairman, Dr. R. M. Yerkes, H. E. Howe

The National Research Council is a cooperative organization of the scientific men of America. It is established under the auspices of the National Academy of Sciences and its membership is largely composed of appointed representatives of the major scientific and technical societies of the country. Its purposes are the promotion of scientific research and of the application and dissemination of scientific knowledge for the benefit of the national strength and well-being.

OUR LEPROSY PROBLEM

THE announcement from Washington by the Surgeon General of the United States Public Health Service to the effect that scientists of the Federal Health Bureau working at the United States Leprosy Investigation Station in Hawaii had discovered in the ethyl esters of Chaulmoogra oil an improved treatment for leprosy is very encouraging, and it is to be hoped that further experience will warrant the optimism with which the new remedy is being received. Chaulmoogra oil, the product obtained by expressing the seeds of an East India plant, has been the mainstay in the medical treatment of leprosy for many years, but unpleasant features associated with its administration have seriously limited its use.

Various chemists have endeavored to secure the active medicinal components free from the constituents that were thought to be responsible for the disagreeable effects, and several of these purer products have been tried by leprologists but scarcely any with the success that appears to have attended the use of the agents employed by the research investigators in Hawaii.

There is an experimental foundation for the use of the derivatives of Chaulmoogra oil in leprosy. The disease is one of a small group due to a member of the "acid-fast" group of micro-organisms. These are germs that have the property of retaining most tenaciously certain dyes with which they may be stained. So strong is the affinity for the dyes in question that treatment with acids fails to discharge the color, hence the term "acid-fast." Recently it has been shown that members of this group of micro-organisms are very sensitive to the action of certain derivatives of Chaulmoogra oil. The members of this special group are killed by the Chaulmoogra oil derivatives in very high dilutions while other groups of organisms require much more concentrated dilutions to be fatally affected. In other words, there is a selective action on the "acid-fasts" by these agents. It is hoped that the same lethal action on the germs in the human body may be brought about. In any event the treatment of leprosy is in a more promising light than it has been before.

The appropriation by Congress of money for a national home for lepers brings the leper problem to us in a more emphatic way than it has been presented heretofore. When we regarded leprosy as a scourge of biblical times or even of the middle ages which remains to this day as an affliction of certain tropical countries or even of our own insular territories, the appeal to our interest was rather remote. But to realize that we have the disease in our own country today and that the prevalence is such as to persuade Congress that the subject must be dealt with by the National Government puts the matter in a different aspect.

The situation is not one that need occasion alarm, but the cold fact is that we have in this country several active centers for the dissemination of leprosy, and the sooner we deal with them in an intelligent fashion the less we will have to fear and to regret. The disease by reason of its very limited contagiousness—it has been shown that but about five per cent of any population is susceptible—should be readily suppressed, but we must not be too sanguine on this score, as experience in many places has shown that the disease is one of the most difficult of eradication that sanitary science is called upon to deal with. The reasons for the lack of immediate success in suppressing leprosy are not entirely clear, but most likely the chief one is the fact that many cases are so slow in development that the victim subjects many healthy persons to contamination before anyone is aware that the disease is present.

One of the most popular misconceptions about leprosy is that it is confined to colored races and that white populations are immune. The truth probably is that all races are about equally susceptible, given the same opportunities of infection.

It is likely in dealing with leprosy that the sanitary authorities will need to consider each case upon its merits. Certain cases of the disease are probably little, or not at all, communicable. Every case must be subjected to searching laboratory study in order that the diagnosis may be made secure and the degree of menace to the community may be estimated.

One of the most curious of the many unusual features of the disease is the fact that it prefers to attack the "male of the species." Wherever leprosy prevails among considerable numbers approximately two male victims to each female are attacked.

The belief, which comes down from biblical times, that leprosy is hereditary has been disproved by modern investigations. It has been shown that when an infant has been removed from a leprous mother immediately after birth the risk that the child will develop the disease is almost *nil*.

We must note that the contagiousness of leprosy varies with the locality. In some portions of the world it exhibits no tendency whatever to spread, while in others it attacks a considerable percentage of the population. The difference in this respect is not solely climatic, nor does it appear to be due to the nature of the surroundings from a sanitary point of view. When we recall that the precise mode of transfer of the disease is not known it is obvious that we must await further developments before we can hope to give a rational explanation for the relative immunity of certain localities.

Leprosy is one of the diseases about which our knowledge is so meager largely because it has not been possible to convey the disease to any of the lower animals in which it might be studied experimentally. Indeed, attempts to transmit the disease to men under artificial conditions have been almost uniformly negative, hence the failure to contaminate animals in which the disease does not occur naturally is readily understood. There occurs among sewer rats a disease strikingly like leprosy in many respects and students of the subject hope that investigation on this analogous disease may lead to useful results which may be applicable to leprosy.

In connection with no disease do we see more unwarranted dread. Indeed public apprehension sometimes reaches the degree of community hysteria, but there is no disease which intelligently handled need cause less apprehension. When the Public Health Service proposed to locate the Government Leprosy Hospital on certain advantageously situated islands off the coast of one of our Southern States, a storm of protest came from the entire Commonwealth; indeed some objections came from adjacent States, and this in spite of the fact that the State in question had a fair number of lepers quite free to come and go as they might see fit.

An organization known as the American Mission to Lepers endeavors to furnish comfort and cheer to lepers wherever they may be found in the United States. It means much to the leper, thrust aside in some isolated corner, to receive a hamper of comforts or a basket of delicacies from the organization, or even better, a friendly visit from the representative of the Mission.

BUBONIC PLAGUE

A MOST encouraging sign of our enlightenment on the subject of pestilential diseases became visible in the past year when bubonic plague appeared at several of our seaports on the Gulf of Mexico. There was no great alarm felt; no quarantine was imposed and no ill-judged methods of eradication such as the burning of infested quarters of cities, which once was regarded as a desirable method of fighting plague, were employed. Doubtless the confidence which the public has in its sanitary officers to control epidemics accounted for the relative indifference with which the announcement of the presence of plague was received.

As a matter of fact those who have given the subject of bubonic plague much consideration feel that the disease can never become a very serious menace in this country.

Our first acquaintance with plague on the mainland of the United States, and indeed of the western hemisphere, occurred about 20 years ago when the disease was introduced from the Orient and effected a lodgment on our Pacific Coast, from which in fact it has never been entirely dislodged though held in such check as to be well-nigh negligible as a menace to life.

Even earlier than this our Pacific insular possessions had become acquainted with the disease which, judged by oriental experience, we had every reason to fear would prove a tragic addition to the lists of communicable diseases with which we would be called on to deal.

The history of plague may be traced in both sacred and profane history of thousands of years ago and it is an interesting fact that in spite of what may be regarded as clear enough indications in these ancient writings of the relation, so well understood now, which the disease bears to rats, the proof of this relationship had to wait until a few years ago, and then it became the basis of our methods of fighting plague.

Bubonic plague may be regarded for all practical purposes as a disease of rodents, chiefly rats, that occasionally attacks man.

As already mentioned it had been noted in very early times that a pestilence prevailed among rodents coincident with plague in man, but the relation between the two was not understood until experiments conducted in India showed that the disease was carried from sick rats to man through the agency of fleas. As it is easier to destroy rats on a large scale than to destroy fleas the former are regarded as the weakest link in the chain of transference of the disease, and efforts are directed against them and with great success.

In a plague outbreak, so far as suppression goes, human cases may be ignored for all practical purposes, for the type of the disease we are considering never spreads directly from one person to another, but is always carried from a rat to a man. Therefore our efforts should be directed to the root of the evil.

Rats are very cunning animals and their utter extermination is not even to be hoped for, but they can be diminished in number to a very great extent, so great as to meet the requirements for plague control. The means of killing rats are traps and poisons. In addition much can be done to starve out the animals. The latter is best accomplished by legal requirements to the effect that anything which serves as rat food shall be made unavailable to rats. Perhaps the best way to cut off the rats' food is to dispose properly of garbage. In an anti-rat campaign the lowly garbage can plays a mighty part. The trapping and poisoning cannot be left to the individual citizen but must be carried on by men under the control of the sanitary organizations.

The trapping serves two purposes: It reduces the number of rats, and it secures rats for the laboratory studies which are necessary to determine the extent and severity of the infection among the rodent population—a very important matter, as intelligent direction of the campaign depends on this.

Plague is one of the many diseases that follow trade routes and shows a tendency to be confined to the more important trade channels. This of course is the result of its peculiar mode of transfer, as the chances of contaminated rats following direct and important trade channels rather than less important ones is obvious. In times past, and indeed to some extent at present, the commercial loss occasioned by quarantines imposed with the object of restricting the spread of plague has been very extensive. Since it has become generally accepted that rats alone need to be considered and as we have very effective means of dealing with rats on vessels, obstructions to commercial intercourse by quarantine has been very much reduced. Vessels can be fumigated at our quarantine stations with sulfur gas or, as has become very popular in later years, with hydrocyanic (prussic) acid gas, so thoroughly as practically to eliminate the danger of any rats surviving and spreading the disease. When ships are allowed to dock at a plague-infected port or when they arrive at a clean port from a plague-infected one, elaborate precautions are taken to prevent rats possibly infected from passing from vessel to shore or vice versa. Metal rat guards are applied to all hawsers, loading is permitted only in daylight hours, gangways must be raised at night, and the vessel must be kept from close proximity to the dock by fenders.

There is another form of plague known as the pneumonic type, which is not so thoroughly understood as is the one referred to thus far. Fortunately we have little to fear from this form, as it has shown no tendency to spread in the United States, though our experience has been confined to one small outbreak.

The pneumonic form we know best by reason of its ravages in North China some years ago. As the name signifies it is a disease which affects primarily the lungs. Thus far the great epidemics in modern times of this form of plague have occurred in cold climates. The information we have indicates that pneumonic plague is transmitted directly from person to person, and that it does not involve any of the lower animals. This form of plague is almost always fatal.

Efforts have been made to fight plague by means of a vaccine and the results are encouraging but cannot at present be regarded as sufficiently promising to take the place of anti-rodent operations. Very encouraging results, however, have been reported from the use of a serum in the treatment of the disease.

Plague is a good example of those diseases our knowledge of which has been extended by experiments on animals. Animal inoculations have given us proof of the mode of transmission of the disease, and on this is based all of our procedures for controlling it.

Animals are also used in establishing the diagnosis of the disease in man and in rats, both matters of great importance in the inauguration and continuation of control measures.

SUBSTITUTES FOR PLATINUM

AN alloy of nickel and iron known as "Platinite" is being used in place of platinum in incandescent lamps. Nickel-chromium is sufficiently resistant to chemical action to render it a fairly good substitute for platinum in the laboratory. Cobalt is even better than nickel when in contact with strong acids. The melting point of gold may be raised by alloying it with palladium producing an alloy known as "Palau." Bureau of Standards tests show this to be superior to platinum in some respects and inferior in others.

Notes on Science in America

Abstracts of Current Literature

Prepared by Edward Gleason Spaulding, Professor of Philosophy, Princeton University

INCREASING THE PROTEIN CONTENT OF WHEAT

Professor W. F. Gericke of the University of California presents, in *Science* for November 5th, the results of investigations on methods of increasing the protein content of wheat

Wheats of the Pacific Coast States are conspicuously low in protein, so much so that western millers are obliged to ship in large quantities of high protein wheat to mix with their domestic wheats in order to manufacture flour of good baking qualities. The cause of the low protein content of western wheats has been the object of considerable investigation on the part of interested agronomists and plant physiologists for the last two decades. Results obtained from these investigations have led to a rather common belief that the cause of the low protein content of Pacific coast wheat is primarily attributable to peculiar influences of climate.

Professor Gericke's investigations show that this belief is not correct, but that the protein yield is correlated with the application of certain forms of soluble nitrogen at different growth periods.

The data collected show a decided increase (about 77 per cent) in the protein content of wheat obtained from the plants that received nitrogen when they were 110 days old over those that were treated with nitrate at the time of planting. The protein content of the wheat obtained from these two different treatments are respectively 15.2 per cent and 8.6 per cent. The data show that for each of the different applications of nitrate made after the time of planting, there was a corresponding increase in the protein content of wheat. As these increases in the protein content of wheat correspond with the length of the period of the different deferred applications of nitrate made after planting, this would indicate a significant relation between the state of development of the plant and the time when nitrate can be most effectively utilized by the plant in the production of high protein wheat. This emphasizes that the physiological status of the plant, as indicated in its different growth phases, is a factor of great importance in the utilization of plant food available to it.

Not only was the protein content of the wheat increased by all of the deferred applications of nitrogen, but the yield of produce, excepting that obtained by the latest application, was much larger from the plants that received nitrogen for the period of 33 to 72 days after planting than those that received nitrogen during the early growing period. The best quality wheat as determined by commercial grading was secured from the plants that received nitrogen 72 and 110 days after planting. This means that the high protein wheat berry was likewise plump and well filled.

Professor Gericke concludes that the results obtained in this investigation show that the low protein content of Pacific Coast States wheats is not due primarily to the climate as such, but to insufficiency of available nitrogen at certain growth periods of the plants. That climate is not without effect upon the availability of the plant food in the soil is obvious, but the emphasis to be laid on the climatic complex is that it affects the nutrition of the plant. This can be both in the kind and quantity of each of the different nutrients that may be available to it. That this availability is an important factor in affecting the composition of plant products is shown by the results of this investigation.

DESERT VEGETATION AND BORON

In the Journal of the Washington Academy of Sciences for October, 1920, Mr. Karl F. Kellerman of the Bureau of Plant Industry presents an article on the effect of salts of boron upon the distribution of desert vegetation.

The disastrous experience of the past two seasons in the use of fertilizers contaminated with varying percentages of borax has sharply drawn attention, Mr. Kellerman says, to the importance of considering boron compounds not only in fertilizer investigations but also in investigations of alkali deposits wherever agricultural developments are to be considered. While geologists are familiar with commercial developments of borax, it has not been generally appreciated by botanists or others interested in the vegetation of the desert regions that extensive deposits of borax are recorded in many localities in the western United States.

It is perhaps a question whether the desolate character of some of the western and southwestern deserts can be directly correlated with the occurrence of borax in quantity within these areas. Apparently no such correlation has been suggested, either by geologists or by engineers or agriculturists interested in reclamation and irrigation problems in these regions. The Smoke Creek Desert, the Carson Desert, Death Valley, and the Mojave Desert are remarkable for their barrenness; and in view of the occurrence of borax in these regions, it would seem to be a fair suggestion as to whether the contamination of borax in the soil might not be responsible to as great a degree as the low rainfall, for the absence of vegetation. Furthermore, those familiar with the topography of these deserts will recall the peculiar absence of vegetation from mud flats even when these are gradually drying out; they occasionally dry into perfectly level plains, hard and smooth, apparently not badly troubled with alkali but with no sign of vegetation.

In view of the records of the rather wide distribution of borax, it seems not unreasonable, therefore, to suggest that the irregular and rather definitely located occurrence of borax may explain the injury to plants on these small areas. Mr. Kellerman in his investigations personally collected small samples in the alkali spots in Kern County, Cal., where plants were either dying or completely absent. Borax percentages of significant size were found in these samples, although, with the rather high content of the white alkali salts in these spots, it was difficult to determine the relative importance of borax and the other salts in the alkali injury.

Plant physiologists have frequently included boron compounds in determining the toxicity of various compounds upon plants, both in water cultures and in sand and in soil, but there are nevertheless differences of opinion regarding the toxic action both of borax and other boron compounds. One of the conclusions is that boric acid seems to be less harmful to the higher plants than compounds of copper, zinc, and arsenic; and, further, that below a certain amount of concentration boron compounds exert a favorable influence upon plant growth.

Mr. Kellerman as a result of his investigations doubts the validity of this opinion, and considers the stimulating effect to be due to a suppression of the growth of competing organisms such as bacteria and molds on the control plants of water cultures and the bacteria and protozoa in the sand and soil cultures. It may also be doubted, he says, whether the conclusion regarding the relative toxicity of boron compounds and compounds of zinc and copper is valid. If one is considering plants growing in natural soil, zinc and copper compounds are certain to become transformed into insoluble compounds much more rapidly and completely than is the case with boron form deposits that represent natural accumulations. Therefore, it may not unfairly be presumed, he thinks, that boron will prove to be a more toxic element than either zinc or copper.

The toxicity of boron compounds to different crops under field conditions has not, Mr. Kellerman concludes, been adequately investigated. His opinion is that it will almost certainly be found that different crops will show a great range in their resistance to borax poisoning, and it is probable that there may be found to be some direct correlation between the action of the plant in absorbing boron compounds and the limit of the toxic concentrations.

Finally, he says, that much additional investigation, both in the field and laboratory, is necessary before it will be possible to determine the significance of borax either in its relation to natural vegetation or its bearing upon agricultural development in irrigation projects or in the use of fertilizers.

THE EFFECT OF LIGHT EXPOSURE ON PLANT GROWTH

THE *Botanical Gazette* for September, 1920, directs attention to the work of Messrs. W. W. Garner and H. A. Allard in determining the effect of light exposure on plant growth. These investigators have grown plants under different conditions of light exposure, and have made a special study of the tendency to become reproductive or to remain vegetative under varying daily lengths and intensities of exposure. Several varieties of tobacco and soy bean were mainly used in the experimental work, although numerous other species of annuals and biennials were used to check the results attained.

Plants were grown in pots, buckets or boxes, and at the desired time each day were moved into dark chambers which were placed in the field. Time of exposure to light varied in the different tests from 5 hours daily to full daylight, 7 and 12 hours being the exposures chiefly used. Checks received full daylight under similar conditions of temperature. Shorter light exposures were all made during the middle of the day, and during the time of highest light intensity, except one series of soy beans which were kept in darkness from 10 A. M. to 2 P. M. daily.

In general, the amount of vegetative growth was proportional to the length of daily exposure to light. The short exposures resulted in short, slender plants of greatly reduced size. Rate of growth was much slower, and the total size attained was reduced. The inception of the flowering or reproductive phase was greatly influenced by length of exposure to light. Many of the species worked with were thrown into flowering and fruiting by the shorter exposures, while with certain other species and varieties, reducing the period of illumination had little effect upon the inception of fruiting.

The authors conclude that for each plant there is a "critical" length of daylight exposure essential to the development of the fruiting phase. The length of this critical exposure varies with each species and variety, but, in many individuals at least, is very much shorter than normal summer daylight. By exposing the plants to this critical length of illumination, the reproductive or flowering phase can be induced at almost any time. By varying this time of exposure, typical biennials, as *Aster linariifolius*, could be made to complete their life cycles within a few months, while annuals, as soy beans, *Solidago*, etc., could be induced to respond as biennials.

Experiments with shading indicated that time of exposure, and not light intensity, is the primary factor involved in determining the critical day. Light intensity reduced to 43 per cent by shading had no effect upon the time of inception of fruiting, although it did give typical shading results on form and amount of growth. Of significance, however, is the result obtained from exposing soy bean morning and afternoon, but keeping it in darkness during midday. Time of fruiting was not materially altered by this treatment, although it was much advanced in the same variety by reducing the exposure to light through leaving in darkness morning and evening. Reducing the water supply reduced vegetative growth and fruit yield, but did not alter time of fruiting in the least. Winter light, supplemented by artificial illumination at night, giving a total daily exposure of 18 hours, acted exactly as long summer daylight in its tendency to retard or prevent fruiting. The authors believe length of day, through its influence on fruiting and seed formation, to be a fundamental factor in plant distribution.

HYBRIDIZATION AND EVOLUTION

IN the *American Naturalist* for June, 1920, Professor E. M. East, in an article entitled "Hybridization and Evolution," gives an account of results obtained in the crossing of two species—*Nicotiana rustica* L. and *Nicotiana paniculata* L.

The cross between these two species gives an F_1 generation intermediate between the two parents, and as uniform in each character as either parental group.

Few of the male or the female gametes are viable, yet by careful attention to pollination, from one to twenty seeds can be obtained in the capsules, where normally two hundred to three hundred seeds are found. These seeds produce an F_2 generation which is inordinately variable. No two plants are similar, and numerous types can be picked out which if found in the wild would undoubtedly be classed as different species. In genetic terms, the behavior of the two species may be described as follows: They differ in an extremely large number of inherited factors; and owing to these numerous differences, many of the otherwise possible combinations of F_1 gametes, are not functional. A huge percentage of expected combinations of both gametes and zygotes are thus eliminated.

The factors which in combination produce normal fertility, recombine in the Mendelian sense, quite as do the factors controlling the form of leaf and flower. The result is that after a few generations of selection one may obtain a variety of strains, uniform within each line, so fertile as to yield capsules with over ninety per cent of the normal quota of seed, and so different from one another that the extreme types are more unlike than the two original species used in the cross.

After three years of selection (F_5), eight such strains remained out of a large series of selections studied earlier. The smallest type was about 20 cm. in height with small smooth oval leaves, and the largest was nearly 200 cm. in height with wrinkled cordate leaves some of which were 50 cm. in length.

These eight strains were crossed in all possible combinations, and every F_1 generation exhibited as high a degree of fertility as that shown by the parents.

These results are regarded by the author as having an important bearing on certain important problems concerning evolution. The enormous variability of the F_2 generations arising from partially sterile F_1 generations produced by crossing species, lead one, he thinks, to suspect that such combinations might be the basis of a great deal of variability responsible for evolution under domestication. A careful survey of the evidence relating to the origin of modern horses, cattle, sheep, swine, dogs, guinea pigs, fowls, ducks and geese on the one hand, and varieties of wheat, corn, barley, oats, rye, apples, grapes, roses and begonias on the other hand, shows that in every case several related wild or semi-wild species exist which will cross together and yield partially fertile offspring. Both the historical and the experimental evidence, therefore, point to hybridization, and particularly to species of hybridization, as the great single cause of evolution under domestication.

At the same time, however, the author says, one must not confuse evolution under domestication with natural evolution. The outstanding biological feature characteristic of the varied groups of domestic animals and of cultivated plants, is the perfect fertility within each group. A marked peculiarity of the great majority of natural species is their sterility with one another, the origin of which has long been a stumbling block to writers on evolutionary biology. His own experimental evidence, as far as it goes, and observations on domestic forms which presumably have originated from combinations of two or more wild species, yield, he thinks, not the slightest indication of a tendency toward the production of segregates that exhibit either incompatibility in crosses or sterility of the individuals produced by hybridization.

Research Work of the United States Bureau of Standards

Notes Specially Prepared for the SCIENTIFIC AMERICAN MONTHLY

INVESTIGATION OF DENTAL AMALGAMS

It is not generally understood how far-reaching the effects of certain scientific investigations may be. To the average person, it seems a far cry from the accurate measurements of length to the development of an improved dental amalgam, yet this is just what has occurred in connection with some of the recent work of the Bureau. A large percentage of all dental work is in connection with amalgam fillings. Early in the war the Surgeon General's Office of the Army was in the market for a very large amount of this material and it seemed highly desirable to determine the ingredients which would make up the best quality of amalgam filling. The War Department, therefore, requested the Bureau of Standards to investigate the subject, and, if possible, develop a specification which could be used to govern the purchase of this class of material.

As soon as the study of the subject was commenced, it was evident that almost every manufacturer of a dental amalgam had a different idea as to what its composition should be. The Bureau, however, believed that as in every other case, there must be some one composition which would best meet the requirements, and that the use of so many different kinds simply indicated that the subject had not received thorough scientific attention. An important requisite in connection with any material used for filling teeth is that the filling shall remain tight over as long a period as possible. Leaks between the filling material and the tooth quickly result in decay. From previous experience, the Bureau had learned that a common cause of loose joints between two dissimilar materials is due to differences in the coefficients of expansion of the two substances. It was, therefore, deemed advisable to determine with the highest possible accuracy the coefficient of expansion of the tooth substance and the various classes of dental amalgams. When this was done, it was found to the surprise of many of those interested, that a large number of the amalgams had coefficients of expansion differing very widely from that of the tooth substance. This means that upon any change in temperature the tooth and amalgam will expand by different amounts and this can, of course, have but one result, a loose joint between the tooth and filling. After a large amount of experimental work, an amalgam was developed, the coefficient of expansion of which was practically the same as the tooth substance. The results of this work were embodied in a formula which became a part of the specifications of the War Department for this material.

During the work, the opinions of many of the leading dentists of the country were secured as to what qualifications should be possessed by good amalgams, and the consensus of opinion thus secured was embodied in the specifications. Recently a lecture on amalgam fillings was prepared by a member of the Bureau's staff and presented before the Dental Society of the District of Columbia. It was gratifying to note that the Society expressed great appreciation of the work which has been done along this line by the Bureau.

DIFFICULTY IN CONNECTION WITH SMALL LENGTH MEASUREMENTS

Certain difficulties arise in connection with the precision measurement of small lengths which make necessary the use of special apparatus for such work. It was mentioned in the notes for last month that a part of the work of the length section of the Division of Weights and Measures is in connection with the determination of the accuracy of fine wire sieves such as are used in the testing of cement. Besides knowing accurately the number of wires per inch in such sieves, it is also necessary to know as closely as possible the diameter of wires. As these are extremely small, the accurate measurement of their diameter presents some difficulty.

A method used for determining this has been to make the measurement with a micrometer microscope having two parallel cross hairs a short distance apart. The microscope is adjusted so that these two cross hairs are parallel to the edge of the wire, the latter coming midway between the two cross hairs. A reading is taken at this position of the microscope. The instrument is then moved so that the cross hairs come upon opposite sides of the other edge of the wire; the difference between the two readings thus obtained gives the diameter of the wire.

Recently an investigation was conducted to determine whether a personal error existed in making readings of this kind. As the result of many observations carried out with the same microscope and wire by different observers, it was very evident that such an error did exist. In other words, no two observers adjust the microscope to exactly the same position to obtain what they consider to be the central position for the edge of the wire between the parallel cross hairs. This error is undoubtedly due to the difficulty in matching a dark and light space represented in the above case by the wire itself and by the vacant space beyond the wire.

The Bureau believes that a more satisfactory way of measuring these small diameters may be secured by the use of a projection apparatus which will throw a shadow of the wire upon a screen a fixed distance away. By obtaining the size on the screen of a wire of accurately known diameter, it is possible to calculate very easily the diameter of any other wire placed in the projection apparatus.

COMPOSITION OF SLUSHING OILS FOR RUST PREVENTION

Technologic Paper No. 176 of the Bureau of Standards contains a detailed discussion of the above subject, an abstract of this paper being as follows:

Slushing oils are materials used for protecting bright metal where it is not practical to use paint, varnish, or other fixed coatings. An ideal slushing oil is one which can be easily applied to all kinds of metal surfaces by a variety of methods. It should coat the surfaces with a sufficiently thick and impervious film to exclude moisture and air (to prevent rusting), should remain in position for an indefinite length of time, and yet be completely removable from the surface without undue labor. The material should itself have no corrosive action on any kind of metal.

This paper contains a discussion of properties and methods of testing, most of which were developed in the course of this investigation, and summarizes results of tests of a number of samples. From a study of numerous laboratory and exposure tests proposed specifications are given. The specifications suggested are based upon properties of the finished product rather than chemical composition. Formulas are given of some satisfactory mixtures, but it is not claimed that these are the best slushing oils that can be made. They are merely cited as examples of easily made preparations which were found to protect metal.

SPECIFICATIONS FOR RUBBER JAR RINGS

The preserving of fruits and vegetables in the home has always been a matter of considerable importance and particularly so during recent years with the prevalence of high

prices for such articles when bought at the retail stores. One essential for successful work of this kind is that the jar in which the food is placed shall be absolutely airtight. Most of the jars used for this work consist of a glass body and cover sealed by a wire device and a rubber ring. These rings should be made of good quality of material with as long life as possible. In order to develop a satisfactory specification for these rings, the States Relations Service of the Department of Agriculture asked the Bureau to investigate the subject and to report upon the most satisfactory material to use for this purpose. The specifications prepared as a result of this work have proved very satisfactory. The States Relations Service has recently asked the Bureau to make another investigation of the subject in order to still further improve the quality of the product. Many manufacturers are already producing jar rings of a high quality but the Government desires to prevent entirely the manufacture and sale of inferior rings.

LIME, ITS PROPERTIES AND USES

A SECOND edition of Bureau of Standards Circular No. 30 with the above title has recently appeared. The object of the circular is to give general information as to what lime is, how it is made, and what it is used for. As the importance of information on this subject can be readily understood, it is believed that an abstract of the paper will be of interest.

Lime is made by heating limestone under certain conditions whereby it is decomposed into an escaping gas, carbon dioxide, and a non-volatile residue, lime or quicklime. This lime, when treated with water, hydrates or slakes if water is used in great excess, and a paste results, but if the amount is properly regulated, the hydration yields a dry powder which is called hydrated lime.

Since natural limestones contain more or less magnesia, iron, silica, etc., the quality of the lime will depend to some extent upon the nature and amount of these foreign materials. It will also depend upon the way the stone is burned.

As a material for building construction, hydrated lime is better adapted than quicklime because it eliminates the labor usually required to do the slaking. It is used very largely as a brick mortar, as an ingredient in concrete, and in the scratch and brown coats of plaster. A particular grade of hydrated lime, noted for its plasticity, is sold as finishing lime and is used for the white coat of plaster.

Limestone, quicklime, and hydrated lime are used to a large extent as chemical reagents in the manufacture of other materials. In some of these industries the quality of the lime is of minor importance. In others, the use of only one of the three forms of lime is satisfactory, and the quantity and kind of impurity which the lime may contain is definitely specified.

Eighteen of the most important chemical industries that use lime are enumerated. Brief descriptions of these industries are given, showing why and how they use lime, and the quality of lime which they require.

A list of the tests of lime which are usually made includes chemical analysis, rate of hydration, plasticity, sand carrying capacity, time of set, compressive strength, proportion of waste, and fineness.

ARTIFICIAL SEASONING OF GAGE STEELS

FOR use in checking up the gages used in manufacturing plants, steel blocks are employed which are commonly known as gage blocks. These have two surfaces an exactly known distance apart, the surfaces likewise being plane and parallel to one another. An important qualification of these blocks is that they shall not be subject to dimensional cnanges over long periods of time. This makes necessary the use of certain special steel alloys and of special seasoning processes. Recently an investigation has been carried out to determine the effects of various artificial seasoning treatments on the permanence of gage steel and this has already progressed sufficiently far to permit of certain conclusions being drawn.

In this work hardened gages were heated in oil at various temperatures and under varying conditions, and also subjected to seasoning by alternate dipping in hot oil and iced brine. The results are as follows:

(1) Short gages (1/8 inch) showed no appreciable changes in length, with or without various artificial seasoning treatments, over a period of approximately 7 months beginning about 1 to 2 weeks after hardening. In general the long gages (2 inch) showed no appreciable changes in planeness.

(2) For studying length changes with time, gage blocks of greater length than those used (2 inches) would be desirable. About 6 to 8 inches is recommended.

(3) Duplicate gages show wide variations in length changes, for example, one block showed no dimensional change in 217 days between the first and last measurements while a duplicate decreased eighteen hundred thousandths of an inch in length in the same period.

(4) Except in the case of plain carbon steel containing 1.18 per cent carbon the changes in planeness are not appreciable. In this steel relatively large variations in planeness for duplicate gages are noted.

(5) Gages produced from stainless steel and ordinary drill rod are softer than reference blocks ordinarily produced and which are kept between about 90 to 100 Shore hardness. From this standpoint, the stainless steel is unsatisfactory as it is not possible with ordinary treatment to maintain the hardness within the limits described. A higher-carbon alloy of this type would be more desirable, with possibly a decrease in chromium such as would not impair its stainless qualities and at the same time reduce production costs.

(6) The plain-carbon steel (containing 1.18 per cent carbon) appears to be the least desirable from the standpoint of permanence, showing in the main the greatest changes in length and planeness during a period approximately 7 months from first to last measurements. Probably the most desirable are steels HC and K subjected to definite seasoning treatments, the former being the steel now generally used in production of reference gages at the Bureau of Standards.

(7) Measurements at intervals of approximately one week, two, four, and seven months after initial readings of length and planeness do not give very much information regarding the progress of the changes taking place. Where the greatest changes occur in either length or planeness they appear to increase progressively with time. In many cases where these changes have been smallest over the entire time interval they seem to occur in the intervals immediately following the first measurement, the gages thereafter remaining constant.

THE STANDARD SAMPLES DISTRIBUTED BY THE BUREAU

ONE of the important functions of the division of Chemistry is the distribution of standard samples of material. These are prepared with great care and before a sample is issued it is analyzed by a number of different laboratories, the results being carefully checked with the values obtained at the Bureau. The demand for these samples is quite large and during the past month 33 new customers were added to the list. During November 434 standard samples were issued on 128 orders; two of the samples being new ones, Nos. 23-a and 51, and consisting of Bessemer 0.8 per cent carbon steel and Electric furnace 1.2 per cent carbon steel, respectively.

A TABLE OF CERTAIN WEIGHTS AND MEASURES

THERE has recently been prepared for distribution a table of equivalents of United States gallons in terms of British Imperial gallons and vice versa, from 1 to 100. The tables also aply to other units of the same relative sizes, such as, for example, U. S. quarts to British Imperial quarts. Another paper containing information on the weight per cubic foot of broken limestone and its dependence upon the specific gravity of the solid material and the percentage of voids has likewise been prepared. The voidage of certain other loose materials, such as sand, gravel, and stone, is also given.

Research Work of the U. S. Bureau of Forestry

Notes from the Forest Products Laboratory at Madison, Wisconsin

RESEARCH IN WOOD AT THE FOREST PRODUCTS LABORATORY

The cutting of timber and manufacture of wood products is the second largest industry in the country and it is also the most widespread. Prior to 1910 research in wood had been conducted in a disconnected way but the total volume of work was small as compared to many minor industries. Very little scientific research work in wood had been done, methods of utilization being based largely on tradition and the customs of the centuries.

The Forest Products Laboratory was established in 1910 by the United States Forest Service in coöperation with the University of Wisconsin in buildings on the campus at Madison, Wisconsin. The work of the laboratory is confined entirely to wood. In this work about 200 scientists, engineers and skilled artisans are employed grouped in the following sections: timber mechanics, timber physics, preservation, derived chemical products, pathology, and industrial investigations.

The great advantage of this laboratory is that all necessary facilities are assembled in one place to undertake any type of work on the single material—wood.

Notes from time to time on the work of this laboratory will appear in these columns. These notes will discuss interesting developments as they take place.

CONVERSION OF SAWDUST INTO CATTLE FOOD

Making the sugar contained in wood available as an easily-digested food has been one of the chemical research problems of the Forest Products Laboratory. Preliminary feeding trials of a product developed has been completed and additional extended trials will be conducted this winter by the University of Wisconsin.

The process of preparing a wholesome cattle food from coniferous wood depends upon the conversion of part of the wood into sugar by cooking it for about fifteen minutes with a dilute acid under 120 pounds steam pressure. In this treatment about 20 per cent of the wood is converted into sugar and the remainder rendered more digestible. The sugars are then extracted from the digested dust with hot water, the acid removed from the resulting solution by neutralization, and the liquor evaporated under reduced pressure to a thick syrup. The concentrated sugar solution thus obtained is then remixed with the residue left after cooking and the whole dried to less than fifteen per cent moisture content. The finished material is darker than the original sawdust, is very brittle, and contains a larger proportion of fine dust.

A preliminary feeding trial, using a product prepared in this way from eastern white pine, was conducted by the Wisconsin College of Agriculture with favorable results. Three cows were fed by the reversal method for three periods of four weeks each. In the first and third periods they were given an excellent ration, consisting of alfalfa hay, corn silage, and a concentrate mixture of fifty-five parts of ground barley, thirty parts of wheat bran and fifteen parts of linseed meal. In the second period hydrolyzed sawdust was substituted for part of the barley, two pounds of sawdust being fed in place of each pound of barley, as it was not expected that hydrolyzed sawdust would have as high a feeding value, pound for pound, as barley. The mixture used during the second period contained about 26 per cent of hydrolyzed sawdust. At no time was any difficulty experienced in getting the cows to clean up this concentrate mixture. The cows maintained their production of milk as well in the second period as in the first and third and showed an appreciable increase in butter fat production. A decided increase in weight was noted during the period in which they were fed the treated sawdust.

While no definite conclusions can be reached from this brief trial, these results do show that cattle may be fed a limited amount of hydrolyzed sawdust and that in this trial the feeding value as a source of carbohydrates or energy was half that of barley. It should be pointed out that hydrolyzed sawdust contains only a negligible amount of protein and in this respect cannot be compared with barley. In both rations used in this trial plenty of protein was furnished by the other feeds used.

CRATING AUTOMOBILES FOR EXPORT

A preliminary study by a packing engineer of the Forest Products Laboratory at eleven automobile and truck plants in the Detroit district indicates that great improvements can be made in the method of crating used by the American car manufacturers. It is probable that in the pressure of getting a large production to make the deliveries that the automobile business of the last few years has demanded, the important matter of safe packing has been overlooked. People were so glad to get a car that they were not greatly interested in the condition in which it arrived. Long strings of gondola cars with automobiles on them unprotected from the hazards of transportation, except for a tarpaulin, have been a familiar sight in the automobile district. But now conditions have changed and better packing is receiving the attention of manufacturers and exporters.

Many defects of good packing and crating were noted in this study. There seems to be a very general practice of end grain nailing of frames. No cases were found where three-way corner construction was used. No use is made of bolts except to fasten parts of the car to the frame.

Manufacturers are about evenly divided between southern yellow pine, Norway spruce and spruce for crating work. One company favored spruce as not so easily split as pine.

The reported cost of boxes varied from $50 for a small automobile to $170 for a 5-ton truck.

The outstanding feature of the study was that at the present time there is no uniform standard practice in boxing automobiles and trucks for export. Research work that it is hoped will lead to standardization has been undertaken at the Laboratory. In view of the probable growth of the export trade in automobiles it is especially important that some uniformity in packing methods be developed at an early date.

PULPING PROPERTIES OF AMERICAN WOODS

The Forest Products Laboratory has carried on an extended investigation over a period of more than ten years and has collected experimental pulping data on practically all the possible species of American pulp woods. These data, in so far as the chemical pulps are concerned, have mainly been obtained from experimental cooks in 100-pound semi-commercial digesters installed at the Laboratory and from studies made on the resulting pulps. It has been found, however, that the general cooking conditions, yield, bleach, consumption, etc., as determined by experimental trials for pulp made from any given wood, compare favorably with the results obtained in commercial practice. The data for the various mechanical pulps were obtained from experiments carried on at the ground-wood laboratory, Wausau, Wisconsin, where a commercial-sized grinder equipment was installed by the Forest Products Laboratory in coöperation with the American Paper and Pulp Association.

The yield of pulp from any given wood depends directly upon the specific gravity of the wood or weight per cubic foot and the pulping method employed. By varying the severity of the pulping treatment both yield and bleach consumption are changed. For example, white spruce sulphite pulp prepared for the manufacture of newsprint paper, would show an entirely different yield and bleach consumption from bleached white spruce pulp prepared for use in a white bond paper. It is, therefore, evident that the character and use of the pulp will largely decide the severity of the cooking operation. Certain woods, such as western larch, containing a high percentage of galactan, which is water-soluble, will show a decreased yield by either mechanical or chemical pulping.

Pulping data are available for woods such as red and white oak and white ash not generally considered suitable for pulp purposes. Many wood-using plants produce considerable tonnage of slabs and mill waste of woods not especially suitable for pulp production, and are interested in a possible outlet for this waste. In some cases, at their direct request, pulping trials have been made on woods known to be unsuitable for pulping purposes.

Information on the pulping qualities of 61 woods, including resinous, non-resinous, and hardwoods, is available at the Forest Products Laboratory. This information includes data as to the weight per cubic foot, fibre length, yield of pulp per hundred cubic feet of wood, bleaching properties for some pulps, range of growth of woods, and common names in diffenent localities.

RELATION OF MOISTURE TO THE PROPERTIES OF WOOD

THAT moisture affects the properties of wood in many ways has been known from time immemorial, and the shrinkage and swelling of wood produced by changes in its moisture content has always been and still is the bane of the manufacturer. The proper control of the moisture factor forms the greatest problem of the wood user. Green wood is of little use for most purposes, and the extraction of the moisture through seasoning or kiln drying without injury such as checking, honey-combing, warping or introduction of internal stresses is an art requiring the highest degree of technical knowledge and skill. That the moisture factor is of basic significance in the use of wood was rudely and abruptly forced upon the attention of this country at the beginning of the war, as it was absolutely impossible to build serviceable guns, aeroplanes, army wagons or artillery wheels without properly dried wood. None was available. The Government turned to the Forest Service for help, where this subject had been studied continuously for the past fourteen years. A method of successfully seasoning the green lumber without injury to its strength had already been developed and used commercially and this was immediately put into application on a large scale, for the drying of the wood for all kinds of war purposes. Moreover, a special dry kiln in which the process could be successfully applied had previously been designed and operated commercially. Over three hundred of these Forest Service water spray kilns were established and the wood dried in time for the emergency.

The Forest Products Laboratory has been studying the problems arising from the effect of moisture upon wood continuously ever since its establishment, ten years ago, and previously to this the relation of moisture to strength and of methods of drying to strength had been studied for seven years by the Forest Service in its former laboratories. The subject is so complex in its nature, however, that there yet remains an immense field unexplored. Especially true is this of the shrinkage relationships and internal stresses. The behavior of a piece of wood during the removal or absorption of moisture or water is not a simple matter but depends upon the interaction of many separate factors whose inter-relation is largely unknown or indeterminable. An idea of the complexity of the problems may be obtained from the following premises:

1. Moisture is contained in wood in two conditions; as free water occupying the interstices in the cells, and as hygroscopic moisture contained intimately associated with the wood substance itself. The wood substance becomes completely saturated with hygroscopic moisture with from 25 to 30 per cent of its dry weight and will then take on no more moisture. However, free water may still enter into the wood to the extent of 100 to 200 or even more per cent of the dry weight.

2. Removal of the hygroscopic moisture alone causes dimensional and physical changes, but under certain conditions the removal of the free water may cause the cells themselves to collapse.

3. Wood becomes soft and somewhat plastic when hot and moist, and hardens or takes a "set" in whatever shape it dries. If it dries under tensile stress it becomes set in an expanded condition and, if under compression, in a compressed condition.

4. Wood absorbs or loses moisture in proportion to the relative humidity of the air, that is, it is a "hygroscopic" material.

5. The rate of movement of water or moisture within the wood itself varies greatly under different conditions. The laws governing this movement are not fully known. It is affected by differences in vapor pressures as well as by capillary action, and in general the transfusion is in the direction of the temperature gradient.

6. The strength and hardness of wood increase with the removal of the hygroscopic moisture. The laws governing this relationship have been very fully determined. But resoaking wood after drying does not restore it to its initial condition when green, the resoaked material being always weaker and more brittle, than the natural undried wood.

7. Shrinkage is different in different directions, being usually twice as great circumferentially as radially and one-fiftieth as much longitudinally.

8. Wood shrinks most when wet and dried slowly at a high humidity and high temperature, and least under the opposite conditions.

9. Brittleness is brought about by long exposure to high temperature.

10. Hygroscopicity, or the property of absorbing moisture from the atmosphere, is slightly decreased but not removed by thorough drying.

From this it will be seen that an unqualified statement as to the shrinkage of different species of wood is almost meaningless, since its amount is dependent upon the factors outlined above. The Laboratory is now undertaking an extensive research on shrinkage and an attempt to determine some of the fundamental laws controlling it.

CARBORUNDUM COATED FIRE-BRICK

THE British Clay Worker, Vol. 29, page 113, discusses a German article on the use of carborundum as a coating for refractory brick. It has been found that with a coating composed of 75 per cent of carborundum and 25 per cent of sodium silicate fire-brick need not be so refractory as without the coating. If the fire-brick are basic, 85 per cent carborundum with 15 per cent of clay may be used and a 0.02 inch coating is sufficient for even the highest temperature. The brick must be thoroughly dry before the coating is applied; it is allowed to dry 24 hours, and is then heated slowly. During this process the coating becomes burned into the brick leaving a firmly adherent glassy veneer of carborundum which resists mechanical injury to a remarkable degree and protects the fire-brick from the chemical action of flames. The coating appears to be insensitive to sudden changes of temperature and in the case of a producer such a coating can be applied to all parts including the fire bars. Gas retorts have been coated inside and out to advantage and where cracks appear they can be repaired with a mixture of 50 per cent carborundum with 50 per cent clay made into a paste.

Progress in the Field of Applied Chemistry

Notes Culled from Current Technical Literature

By H. E. Howe, Member of American Chemical Society

DYES AGAIN

Mr. Edward S. Chapin, the Paris representative of the Textile Alliance, Inc., has recently made his report to the Dye Advisory Committee of the Department of State and discusses the situation under four headings, namely, the Herty Option colors, the reparation colors from the impounded stocks, German dye products in the future, and general comments.

It appears from the report that the Germans are laying aside twenty-five per cent of their daily production to be allocated to the Allies in accordance with class and percentage and on the fifteenth of each month submit a statement of the twenty-five per cent due the Allies from their productions of the previous month. Every color produced is included and the price to the Allies is the lowest price quoted during the month of production to any buyer. The following is quoted from the report:

"A brief analysis of the quantitative and qualitative production of the German factories for the past six months will be of interest.

"The total production of the German factories in the month of February, the first month for which a daily production list was submitted, was 1,600 tons, approximately 10 per cent of their pre-war capacity. This production has steadily increased; 2,400 tons in March, 3,300 tons in April, 3,800 tons in May, 4,800 tons in June, and 5,500 tons in July, thus from approximately 10 per cent of their pre-war capacity in the course of six months to 33 1/3 per cent.

"From the standpoint of consumers of dyestuffs in the United States this rapidly increasing production on the part of the German factories is not so satisfactory as might at first appear, for a large part of the increase in production is not the Herty Option colors, the colors desired by the consumers in the United States, but the big bulk colors, the colors that are being made by American manufacturers.

"Take the three months—May, June and July. The total production by all the German factories of vat colors and fast Alizarine colors, which are especially desired by consumers in the United States was approximately 800 tons. During the same period the production of Indigo 20 per cent paste, direct cotton colors, acid colors, and sulphur colors amounted to 8,800 tons, that is to say, eleven times as much as the production of vat colors and fast Alizarine colors.

"Further, while the production of the vat and Alizarine type dye is increasing slowly from 228 tons in May to 261 tons in June and 272 tons in July, the production of the type dyes made in the United States is increasing by leaps and bounds, from 2,400 tons in May to 2,800 tons in June and 3,800 tons in July.

"The large German production of dyes of the same type as are being made in the United States is evidence of the necessity of special protection for the American industry. The relatively small German production of dyes of the Herty Option type explains the 23 per cent of the first six months' allocation orders still to be delivered.

"The question naturally arises whether the Germans cannot produce more of the special colors desired by the United States. The arrangement which is being considered by the Reparation Commission aims to effect this purpose. The Germans do not like the necessity of putting aside 25 per cent of every color which they make during the month for the Allies and especially dislike the necessity of holding this 25 per cent against future orders, more or less problematical. Accordingly the Germans are inclined to consider a permanent proposition which will do away with the necessity of their putting aside 25 per cent of their daily production. The future of the supply of German colors to the United States is linked up with this permanent proposal. According to all indications when I left Europe it seemed almost certain that the permanent proposal would be adopted in the course of a few months."

DETERMINATION OF THE PERMEABILITY TO WATER OF SOLE LEATHER

The following abstract of an article by E. Jalade in *Le Cuir*, IX, 372-77 (1920) occurs in the November Journal of the American Leather Chemists' Association and is interesting in view of the wide application of leathers for service where permeability to water is a major factor:

"The permeability of sole leather is influenced by a number of factors and the effect of the degree of tannage of the leather has already been discussed (that journal, 15, 537-42). It is important to recognize that the degree of tannage is usually greatest in the grain layer and least in the region between grain and flesh. In a sample having a degree of tannage of 73, the degree of tannage of the grain layer was found to be 80, of the flesh layer 62, and of the middle layer only 57. Contrary to the prevailing opinion, the grain is not highly resistant to penetration by water; we found leathers to have the same resistance both before and after the grain had been removed. Bleaching materially increases the permeability of leather to water; a certain make of leather was penetrated by water, under a 20 cm. column, in 50 minutes before bleaching, but in only 5 minutes after bleaching. A false resistance is produced by coating the grain with a drying oil and also by high water-soluble content. A leather containing 21.50 per cent water-soluble matter required 24 hours for penetration, but when this soluble matter was washed out and the leather was again dried, water would penetrate it in 30 minutes. Low degree of tannage, excessive tannage to get high yields, washing after tanning, and bleaching all cause the leather to have poor resistance to water. Few leathers are very resistant. Out of 100 samples examined, 52 were penetrated in less than 30 minutes and only 13 required more than 4 hours."

METALLIC ARSENIC

Pure metallic arsenic is the subject of an interesting discussion of a plant which produces a quantity of metal equal to the requirements of the United States, together with notes on the properties of the metal and its uses by Chester H. Jones in the November 17th issue of *Chemical and Metallurgical Engineering*. The following uses quoted from the article in question will be of interest:

"The metal acts in the nature of a flux for other metals, promoting the union of metals which would otherwise be difficult to mix. The trioxide cannot be successfully substituted for the metallic arsenic in the work. Arsenic bronze, now used for railroad brasses, is a good example. (Composition: Copper 80, tin 10, lead 10, arsenic 8.) The structure remains unchanged, but there is a gain in crushing strength and a lower temperature is required to crystallize. A content of 0.65 metallic arsenic increases the resistance to hammering.

"The arsenic may be added directly to the molten metal, or a rich alloy of arsenic with copper or lead may be made and proper proportions of it used.

"It seems to be the consensus that a small percentage of arsenic added to copper to be used in sheets, tubes, staybolts, etc., for locomotive fireboxes will increase the tensile

strength, rigidity, hardness and resistance to action of gases as compared to pure copper. Added to copper for castings it reduces blow-holes and increases fluidity. Copper to be drawn into wire works better in the drawing process and the melting point and conductivity are lowered.

"The annealing point of copper is raised by the addition of arsenic, and a tougher metal results. The injurious effect of small quantities of bismuth is counteracted. Arsenic tends to deoxidize the copper.

"A higher percentage of lead may be carried in a zinc alloy by the addition of metallic arsenic.

"When added to brass for casting up to 0.5 per cent, it increases the fluidity when molten, gives sharper and cleaner castings and increases the strength and elongation. It increases the ductility of Muntz metal (60 copper, 40 zinc).

"A finer grain and increased hardness is secured by adding metallic arsenic to white bearing metals.

"Arsenical lead contains about 2 per cent arsenic. The product is harder, but the more important property of increased mobility of shot when molten is secured. This results in a more uniform output from the shot tower.

"Metallic arsenic is also used in the manufacture of speculum metal for mirrors in large telescopes."

SPECIAL ALLOYS

A PATENT has been granted to Foster Milliken for three new alloys. One of these is reported to be acid resistant as well as resistant to high temperatures. Its composition is as follows:

Iron	16 to 20%
Chromium	5 to 7
Copper	31 to 38
Nickel	38 to 46
Manganese	½ to ¾

Another is said to be resistant to high temperatures, to alkali and chemical mixtures at such temperatures, and has the following composition:

Copper	50 to 60%
Nickel	28 to 36
Zinc	4 to 8
Iron	4 to 8

The third is recommended for the manufacture of valves, particularly those used in handling gasoline and light petroleum distillates and has the following composition:

Lead	10 to 14%
Copper	55 to 65
Nickel	6 to 11
Zinc	14 to 18

THE MANUFACTURE AND USES OF ROLLED OPTICAL GLASS

THIS is the subject of a report issued by the Geophysical Laboratory reprinted from the American Ceramic Society and reports in detail researches conducted by members of the Laboratory staff during the war period when quantity production of glass suitable for military optics was so imperative. It had long been argued that the method whereby rolled plate glass is prepared could not be applied to the production of optical glass where striae are of such consequence, but it was found that rolled optical glass has the striae in the form of plain parallel films which in general are quite invisible unless viewed edgewise. If optical systems can be prepared from such glass so that the path of light rays cuts the striations in a direction as nearly normal as possible to the directions of the striations themselves no difficulties are encountered in most cases. The paper discusses the method of manufacture which in general is a combinaiton of stirring and earlier processes used in making ordinary optical glass with the casting, annealing, grinding, and polishing, which is common to the manufacture of rolled plate glass. This process was carried out extensively during the war period and produces glass suitable for the majority of optical instruments used in warfare, for spectacles, photographical lenses, field glasses, and low precision instruments in general. No claim is made that rolled optical glass is suitable for optical systems of the highest precision.

THE MALTOSE SYRUP SITUATION

IN *Chemical Age* (New York), October number, there is a discussion of the maltose syrup situation. It will be recalled that many breweries engaged in the manufacture of maltose as a new product employing most of their usual equipment. This was at a time when there was great need for a substitute to supplement the sugar supply and when the price of cereals made competition with the better known glucose much easier than it will be in the future with the decline in the price of such cereals. The industry affords an excellent example of how essential chemical control is to the success of such an enterprise for several producers lacking technical ability have not been able to prepare syrups in quantity equal to samples nor satisfactory for some purposes. On the other hand, maltose syrups today are satisfactory for bakers' uses, for branches of candy manufacture, table syrups, ice cream production and so on. In some beverages it has not been satisfactory, due to the malt taste and some syrups have been too dark in color for certain applications.

Maltose syrup is undoubtedly destined to create a market for itself, based upon its own intrinsic value and because for some applications it is better than its competitor, glucose. There seems no doubt but that maltose is now going through stages similar to those which glucose survived several years ago and as the manufacturers become better able to instruct prospective users of the syrup as to its uses it will undoubtedly gain a firm foothold among the trade. It seems certain that in the future, maltose must be nearly water white, clear, and free from malt odor and taste. This will require scientific supervision and to meet competition there will have to be large scale production.

THE EFFECT OF CERTAIN AGENTS ON THE DEVELOPMENT OF SOME MOLDS

THIS is the subject of a very interesting monograph by K. G. Bitting, bacteriologist of the Glass Containers' Association of America, which has just come from the press. The writer has been engaged in food research for a number of years and during the period has been impressed by the claims of many manufacturers that spices and other condimental agents may be used as preservatives. A series of investigations were undertaken with a variety of such agents using three typical molds and observing the effect upon these organisms of the re-agents used in various amounts. These included the oldest and most generally used, namely, salt, sugar and potassium nitrate, the common spices and aromatics, a series of vegetable acids either found in, or commonly added to, foods such as vinegar, cider, malt, acetic and citric acids, preservatives which have been and are used in foods, including benzoate, alcohol, salicylic acid and the like, certain antiseptics, the mineral acids, two common alkalis and some very active drugs and poisons. So far as could be judged the older preservatives, namely, salt, sugar and potassium nitrate, cause no permanent injury to the molds, the effect produced generally being merely plasmolysis. The spices and aromatic substances of ordinary household use possess in general little or no antiseptic value. All-spice, cinnamon, and cloves show the highest antiseptic values and consequently tests were made to determine the amount of the active principle extracted from each during the process of heating so that more accurate data might be available in judging the preservative action. Reckoned on the amount of spices commonly added to a batch of catsup and the amount of the active principle extracted, it was found in the case of all-spice that the active principle would be present in catsup in the proportion of 1 to 90,000. Authorities give the antiseptic values of oil of all-spice as 1 to 140 and 1 to 180. The antiseptic property of the oil is ascribed to

eugenol which is present in the proportion of 65 per cent thus being present in the batch in the proportion of 1 to something over 138,000.

In the case of cinnamon the active principle present would be in the proportion of 1 to nearly 259,000 and in cassia, the form generally used in place of cinnamon, 1 in nearly 130,000 whereas the highest rating accorded by a scientist is 1 to 2,100. These figures indicate that very little of the antiseptic is obtained ordinarily from the spices in food in which they are cooked for a short period. The spices could be used in amount sufficient to heighten antiseptic effect but the great concentration of flavor would be intolerable.

Interesting summaries accompanied by detailed tables are given for all seven groups of materials employed as well as for mixtures of the re-agents and the monograph concludes with an extensive section of photomicrographs showing the state of the molds in question after incubation in tomato bouillon or other media to which various proportions of the re-agents were added.

SOURCES AND PRODUCTION OF IRON

Attention is called to the 1918 report on the sources and production of iron and other metalliferous ores in the steel industry, this having been compiled under the direction of the Department of Scientific and Industrial Research of Great Britain. The report is in three parts, the first consisting of notes on the iron ores of the United Kingdom and British Dominions, the second on the iron ore deposits in foreign countries, and the third, notes on the ores of the principal metals other than iron used in the iron and steel industries. The statistics of production of iron ore are given by the counties of Great Britain and Ireland and in considerable detail for all of the British Dominions. These details give something of the history of the particular deposit, an indication of the geology of the region, the types of iron ore to be found there and placement in the region, and an analysis of the typical ores. In some instances ownership is indicated and the annual production is also included. In instances where returns are incomplete this is noted. Frequently the analyses are complete and should be of considerable reference value.

As for the foreign countries, all are included insofar as the data has been published. In fact, the available resources of a particular country are summarized and frequently import and export data are given. The ores of metals other than iron used in the iron and steel industries are given as chromite, ferrochrome, cobalt, manganese, manganiferous ore, ferromanganese, molybdenite, ferromolybdenum, nickel, titanium, titaniferous ores, ferrotitanium, metallic titanium, tungsten in its different forms, vanadium, ferrovanadium and zirconium.

This information is treated geographically; characteristics, world production, and prices are included. In the case of zirconium a short bibliography of principal articles and papers on the subject is furnished. The report is to be obtained from H. M. Stationery Office, Imperial House, Kingsway, London, West Central 2, the price being two shillings.

COLLOIDAL FUEL

At the last meeting of the American Chemical Society, Dr. Shepard of the Eastman Kodak Company presented an important paper on colloidal fuel which has been discussed so much of late. In extensive tests, this fuel gave results equal to naval fuel oil and was found satisfactory on submarines even after three or four months' storage. On the average this fuel contained 31 per cent of pulverized coal and yet possessed the properties and flexibility of oil being capable of handling like oil and possessing its flexibility for manufacturing purposes. Various grades of carbon material may be employed, realizing an economy of from 25 to 50 per cent of the oil used. This fuel has very little moisture or ash and is as compact as oil but with more heat units per gallon. It is not subject to spontaneous combustion, does not generate explosive vapors, and can be water-sealed in storage and water-quenched when ignited. This makes its fire risk as low as anthracite. Its combustion efficiency in steam raising per British Thermal Unit per pound is said to be equal to fuel oil and its method of preparation has been so perfected that its life in storage is from one week to one year, according to the grade. By life is meant the length of time which it can be stored without a separation of the pulverized coal or other carbonaceous material from the oil in which it is suspended.

WATCH OILS

The oil which has heretofore been considered satisfactory for the lubrication of time pieces has been prepared almost entirely from the maxillary fat accumulations of the porpoise. There has been some oil prepared from other fish and such oil has sold for about $250 per gallon. Dr. C. F. Mabery has now perfected a process whereby a satisfactory grade of lubricating oil for watches and clocks and other fine mechanisms can be prepared from crude petroleum. His experiments thus far have been on oil from the Mecca field and a company in Ohio has begun the production of this high grade product on a commercial scale.

HYDROGEN

A patent has been granted to the British Oxygen Company for a new process of preparing hydrogen. Ordinarily hydrogen has been prepared by the iron-steam process in which the waste gases of reduction have not been fully spent in passing through a retort. These gases, which still contain reducing gases, are to be treated by the new process for the removal of the steam and some water vapor, carbon dioxide and sulphur dioxide, and other sulphur compounds, after which it is passed to another retort where it effects the reduction of the charge in it. The waste gases may be passed into the furnace setting or discharged into the atmosphere. The process may be carried out with three sets of retorts operated so that while the first is making hydrogen, the second may be receiving water gas to completely reduce the charge in it, and the spent gases from this set after treatment as described may be passed to the third set. The next step would be for the second set to make hydrogen while the others take up the cycle in the order named above. The purification of the spent gases is effected by first passing them through a scrubber packed with marble and coke down which water trickles to remove the sulphur, then washing to remove carbon dioxide and finally passing them through a condenser to remove steam and water vapor.

CHANGES IN CYANAMID

In the November issue of the *Journal of Industrial and Engineering Chemistry* there appears a paper by N. R. Harger on the changes taking place in cyanamid when mixed with fertilizer material. A great deal of research has been done on changes which take place when cyanamid alone is added to the soil or is kept in storage, but relatively little attention has been paid to changes which may occur in the material when this extremely reactive substance is mixed with the other fertilizer materials. There has been indication in some areas that mixed fertilizer containing cyanamid is somewhat toxic to plants but heretofore no experiments on the question have been reported. In the experiments under discussion the following mixtures were used (1) acid phosphate and cyanamid; (2) potassium sulfate, acid phosphate, and cyanamid; (3) ammonium sulfate, acid phosphate, and cyanamid; and (4) dried peat, acid phosphate, and cyanamid. The paper discusses the chemical changes involved and gives experimental details together with analysis, the author having devised a rapid method which is direct, for the determination of dicyanodiamide which has been found to be the substance into which cyanamid is changed under the conditions obtained. While further investigations are under way the results which so far have been ascertained lead the author to reach the following conclusions:

1. When cyanamid is mixed with fertilizer materials con-

taining acid phosphate and 5 to 10 per cent of moisture, the cyanamid content decreases with great rapidity.

"2. This change is represented partially by, and in the higher concentrations principally by, the formation of dicyanodiamide.

"3. A given quantity of moist acid phosphate is able to transform a limited amount of calcium cyanamide.

"4. Cyanamid is not affected by dry acid phosphate.

"5. Moisture alone is able to cause the conversion of cyanamide to dicyanodiamide, but the change is much slower than when acid phosphate is present.

"Since it has been repeatedly shown that dicyanodiamide is valueless as a fertilizer material, and, moreover, is toxic to many plants, the formation of this compound in fertilizer materials seems undesirable. On first thought, it would appear that this conversion of cyanamide into dicyanodiamide could be avoided by employing dry fertilizer mixtures, but this overlooks the fact that when such mixtures are added to the soil, moisture conditions are at once provided, and the transformation may possibly then take place. Preliminary experiments carried out in this laboratory indicate that, under certain conditions at least, this is the case.

"It should be noted that these unfortunate reactions between acid phosphate and cyanamid do not in any sense imply that cyanamid cannot be successfully used when mixed with other forms of phosphate. In this connection it should be noted that the Fixed Nitrogen Research Laboratory of the Ordnance Department has called our attention to the fact that lime nitrogen (cyanamid) can be mixed with calcined and basic phosphates without the excessive production of dicyanodiamide noted when moist acid phosphate is used."

THE AMERICAN INSTITUTE OF BAKING

The American Institute of Baking has issued its first annual report which gives details as to progress made in organizing and establishing this new research body which brings to the aid of one of our oldest industries the assistance which modern science affords. There have been individual instances where the larger bakeries have called science into the workroom and the progress resulting has been a factor in persuading the bakers in general to accept such assistance. Besides enjoying the assistance of an advisory board composed of eminent specialists appointed by the National Research Council, the Institute has benefited by an arrangement with the University of Minnesota by which students in the graduate school, candidates for advanced degrees, and who are interested in problems which concern wheat fermentation, gluten development or other problems with a practical application to the baking of bread may conduct their work in the laboratory of the American Institute of Baking. A baker's short course has been devised and one important function of the Institute is to afford means for specialized training for those engaged in the industry. The literature of breads, yeasts and fermentation, as well as of cereals and the baking industry in general is being compiled with the aid of the indices of the Library of Congress, Bureau of Chemistry, and the Department of Agriculture, and extensive steps are being taken for complete coöperation with other interested associations.

The work thus far undertaken involves standardizing baking materials and preparing specifications upon which they may be purchased, which is in itself a very large problem since such materials as flours are indeed difficult to standardize. However, standards have been established by state and federal departments for such substances as oil, fats, lard, condensed and dried milk, sugar, and hydrolized starch products. Some other interesting questions are: what is an ideal loaf of bread and is it possible to standardize the loaf? For ages a loaf of bread has been simply a loaf of bread and there have been no units by which it could be standardized. The products of a number of successful bakers, if brought together, would be quite dissimilar as to shape, size, weight, color, flavor, texture, crust and crumb. Problems which at present confront the Institute include a study of rope infection in bread and its control, a study of acidity control in bread making and its relation to length of fermentation, composition and enzymic activity of malt preparations, methods of analysis, moisture retention and staleness, and a study of the methods and materials used in the wrapping of bread and the effect of these materials upon the content and package. Advice is being given the industry on shop problems and raw materials are being analyzed.

PRICKLY PEAR

The Journal of Industries, which is issued by the authority of the Minister of Mines of Industry of the Union of South Africa, in the September number gives the second of the articles by Dr. Juritz on the prickly pear and the possibility of its utilization. The author has already discussed in other publications the possibility of using the prickly pear as a source of industrial alcohol. To make alcohol production from this source profitable it would appear necessary to produce a large amount of fruit from small areas which, to make collection economic, should bear ten tons of fruit to the acre. There would also have to be devised a less expensive method of collecting than hand picking. This question, by the way, has already been investigated in New Mexico and the problem appears to be only one of economics. There is a possibility of certain species of prickly pears being used for the sake of a mucilaginous substance which can be obtained from it. It is also suggested as a source of oxalic acid, since crystals of calcium oxalate are contained in all parts of the plant in comparatively large proportions and some other oxalates are to be found in the liquid condition. The prickly pear is also suggested for paper making, but the pulp which has so far been prepared in experiments appears to consist of short fibers which would have a low value and as is so often the case with such plants, the yield per ton of raw material is small and the amount of re-agents required relatively great.

A dye or coloring matter of a light magenta shade can be extracted without difficulty from fruits of certain kinds of prickly pear and this dye from the species which occur on the high mountains of Argentina has been used locally for dyeing wool. There is, however, a great deal of research necessary before recommendation for commercial venture in this field could be made. As a source of oil the great difficulty appears to be again in the collection of material and the low percentage of oil in the seeds of the plant would appear to make it commercially impossible. The plant has also been suggested as a basis for soap manufacture, but there is nothing to indicate that this suggestion can be considered seriously. The article concludes with a number of minor uses, but such applications as are named are not such as to encourage any commercial development.

ARTIFICIAL WOOLENS

In the *Color Trade Journal* for September a note from the Textile Mercury on imitation woolens appears. The treatment has been patented in England and is designed to impart to vegetable fibers appearance, feel, and chemical and physical properties resembling woolens. The cotton is impregnated by means of a solution of cellulose in concentrated nitric acid and then treated with water to precipitate upon the fibers a slightly nitrated cellulose. After pressing and washing the nitro cellulose remains firmly adherent to the fiber. Its treatment increases the weight of the material and renders it possible to absorb a greater quantity of basic colors.

An example of operating according to the patent is to introduce rapidly and with constant stirring thirty grams of cotton waste or wood pulp thoroughly disintegrated and bleached into a thousand grams of 81 per cent of nitric acid at a temperature of 15 to 20°C. When the mixture has become a syrupy mass add 110 grams of water. Allow this solution to cool and then immerse in it the fibers or material to be treated, allowing it to remain for a time without tension; then squeeze and wash.

Progress in the Field of Electricity

Summaries and Excerpts from Current Periodicals

By A. Slobod

SOME RECENT APPLICATIONS OF THE AUDION

Mr. Lee De Forest, reviewing the development of the audion in an extensive paper read before the Franklin Institute, brings out some very interesting applications of this apparatus and forecasts the use of it in many new directions. Most striking is the suggestion of producing music electrically. To quote the author: "The uniform generation of electrical oscillations in a circuit by means of an audion is one of the most fascinating of its applications. If these are of radio frequency there is no sensible manifestation of their presence, but if of audio-frequency the telephone receiver or "loud speaker" reproducer may be made to give forth sounds from the highest pitch or volume to the softest and most soothing tones. Such wide range and variety of tone can be produced from suitably designed singing circuits that a few years ago I prophesied that at some future time a musical instrument, involving audions instead of strings or pipes, and batteries in place of air, would be created by the musicians' skill."

There seems to be no limit to the number of applications to which the audion can be applied as a tool in the hands of the experimental physicist. Very recently Prof. Blondel has utilized the audion in a balanced bridge method for measuring excessively slight differences in static potentials. Again, as low frequencies, even to one oscillation per second can be obtained from the audion, pulsations suitable for submarine cable signaling, or for chronograph and time-pendulum work, can be had of remarkable constancy and reliability, free from all difficulties of speed regulation of motors, or of any moving parts. Of especial value is the fact that it renders easily available devices having negative electrical resistance, as in the four-electrode device of Dr. Hull; for one fundamental property of the audion is that an electrical influence in one circuit may, through the grid, be made top roduce effects in another circuit without appreciable reaction. The energy absorbed by the control electrode may be considered negligible—frequently less than that required in moving a galvanometer needle. Then, and probably the most promising field of all, the arrangement of audions in cascade as amplifiers of pulsating currents of any form or frequency opens to the ear what the microscope has given to the eye—new regions of research in numerous and diversified fields, from physiology, for heart beats and breath sounds, to chemistry, where some even predict that we shall some day hear "the collision of individual atoms with one another."

DAYLIGHT BIOSCOPE PERFORMANCES

Repeated attempts have been made lately to obviate the necessity of a darkened auditorium for bioscope performances. Fortunately, some of these attempts have been crowned with success, and some apparatus have been devised which may now enter into competition with the old appliances requiring "lights out" for the performance. The study of the problem before the inventor soon made it evident that two solutions only were possible: either the picture had to be reflected by an opaque screen as heretofore or by a transparent one with the operator behind it. The adoption of the latter alternative, however, found most favor and success, and the desiderata for its execution can be described briefly as follows: (1) The picture must show sufficiently bright and distinct, even with the daylight or artificial light upon it. (2) Evenness of the screen and sufficient fineness of grain. (3) Clear and brilliant white tints of the picture. (4) Uniform diffusion of the light rays of the projector lamp, to ensure an even illumination. (5) Perfect smoothness of the screen.

The "Daylight screen" of the Deutsche Lichtbild-Gesellschaft meets all these demands to their fullest extent. Under reflected light the screen shows a deep black color which perfectly absorbs all light rays, whereas, under transparent light a clear white color appears, which even in the glare of daylight produces a picture, distinct luminous and exceptionally brilliant. The rays of the projector lamp are so well and so regularly diffused that not only a perfectly even luminosity of the screen but also an absolute invisibility of the light source has been attained.

This result can be arrived at in two different ways. Either the apparatus is connected with the screen by a tube which carefully excludes every bit of light from the outside or a dark room is built on the stage behind the screen. Both tube and dark room serve to exclude all possibility of light coming in from the outside. The former type is mostly adapted to schools, private entertainments, etc. In this case a bellows is attached to the apparatus permitting of a very accurate focusing of the picture. The second type is usually employed at theaters or theatrical performances; here the transparent screen is suspended close to the footlights, while from the stage itself all light from the outside is carefully barred by black curtains. When the screen is not in actual use it is raised like the ordinary curtain, thus freeing the stage for other entertainments. Should the space behind the screen prove too short for the installation of a dark room, it may yet be adapted for the use of the daylight screen, inasmuch as the focal distance can be increased by first throwing the light rays from the projector lamp vertically upward on a mirror fixed above at an angle of 45 degrees, and from there by way of another mirror fixed at the same angle, on to the screen.

There can be little or no doubt that the apparatus described above will considerably extend the scope of cinematography. It will be of special service to the teacher who may have to watch his pupils during the performance. To enable him to do this or to interrupt the performance suddenly for the purpose of explaining the picture, a special, skilfully worked out stopping device has been attached to the projector lamp which permits him to arrest the moving picture at any given moment. For advertising and entertaining of any kind this new apparatus will in the future be found quite indispensable. —*Engineering Progress*, July-August, 1920.

THURY SYSTEM OF DIRECT CURRENT TRANSMISSION

In *General Electric Review* for November, 1915, Mr. William Baum gave an exhaustive review of the Thury system and its European installations. Interest in this system has not been lacking also in this country. Of timely interest is, therefore, the article by Prof. Alfred Still in *Electrical Review*, Chicago, for August 7, 1920, briefly describing its advantages and disadvantages.

In Europe underground cables are usually preferred to overhead wires when the distance of transmission is not great, and the Thury system is used in about 16 independent transmission systems utilizing direct-current pressures up to 100,000 volts. The high voltage is obtained by connecting a number of generators in series; the pressure across any one commutator does not exceed 5,000 volts. While not going into details of this system, the author believes that occasions may arise, even in this country, where its peculiar advantages over the alternating-current system may lead to its adoption, provided the engineer will have an open mind and refuse to be governed by custom and prejudice.

The advantages of the Thury system are as follows: (1) The

power-factory is unity—a fact which alone accounts for considerable reduction of transmission losses. (2) Higher pressures can be used than with alternating current, the conditions, as shown by actual tests, being more favorable to direct-current transmission than is generally supposed. Without any alteration to insulation or spacing of wires, approximately double the working pressure can be used if direct-current is substituted for alternating-current. (3) The necessity of two wires only, in place of three, effects a saving in the number of insulators required and leads to cheaper line construction. (4) Where it is necessary to transmit power by underground cables, continuous currents have great advantages over alternating currents. Single-core cables can be made to work with continuous currents at 100,000 volts. By using two such cables and grounding the middle point of the system it is, therefore, quite feasible to transmit underground at 200,000 volts. (5) There are no induction or capacity troubles and no surges or abnormal pressure rises due to resonance and similar causes, such as have been experienced with alternating currents. A number of generating stations can easily be operated in series, and when the demand for power increases, a new generating station can be put up on any part of the line if it is inconvenient to enlarge the original power station. (6) The simplicity and relatively low cost of switch-gear is remarkable. A switch pillar with ammeter, volt meter and four-point switch is all the necessary equipment for a generator. The switch pillar for a motor includes, in addition, an automatic "by-pass" which bridges the motor terminals in the event of an excessive pressure rise. This compares very favorably with the ever-increasing, though in some cases unnecessary, complication and high cost of the switching arrangements in high-tension power stations on parallel systems. (7) For any industrial operation requiring a variable-speed drive at constant torque, the Thury motor, without constant-speed regulator, is admirably adapted. It might have a useful application in the driving of generators supplying constant current to electric furnaces in which the voltage across the electrodes is continually varying.

The disadvantages of the Thury system are: (1) The relative smallness of the generators is objectionable, the output of each generator being limited by the line current and the permissible voltage between the collecting brushes on the commutator. (2) With constant current on the line, the line losses are the same at all loads, and the percentage power loss in the conductors is inversely proportional to the load. This is exactly the reverse of what occurs on the alternating-current parallel system, in which the percentage line loss is directly proportional to the load. (3) The series system is less suitable than the parallel system for distribution of power in the neighborhood of the generating station. It is essentially a transmission system, and not a distributing system. (4) Special regulating devices are necessary to maintain constant speed on the motors. (5) It is impossible to overload the motor, even for short periods. This would be a very serious objection to the use of these motors in connection with electric traction systems.

ELECTRICALLY-OPERATED STEAM BOILERS

Based upon the existing conditions of high fuel costs and cheap surplus hydro-electric power, numbers of Swiss manufacturers have introduced electrically-heated steam generators. Some of these have been in operation for several years. A typical generator of this type is the "Revel" boiler, manufactured by the Escher Wyss & Co., Zurich, Switzerland. The main features of this type of boiler are the stationary diving-electrodes which penetrate the cover of the apparatus through openings. The cover is removable. The boilers are of compact construction so that they are subject to but trifling losses of heat due to radiation. The delivery of electrical current to the boiler is regulated according to the quantity of steam required, and is easily arrived at by simply varying or lowering the water level of the boiler. Steam production can be continuously and easily regulated within the extreme limits of capacity of the boiler. After a lowering of the water level, the boiler still remaining under pressure, if the steam stop valve has been closed, the generator absorbs a quantity of electrical energy exactly in accordance with the losses due to radiation of heat, and is always ready for further extraction of steam. Even a low water level in the boiler does not involve any danger, as in the case with ordinary fixed boilers. The lowering of the water level in the boiler is, for the Revel type, a feature of normal working operation.

The performance of a typical Revel boiler is, according to tests conducted by the Swiss Association of Boiler Proprietors, as follows: One kw.-hr. converted 2.83 pounds of water from 50° F. into steam 212° F., and therefore the efficiency of evaporation was 95.7 per cent. The electrical energy used was only 146.7 kw. per hour, although the boiler had been designed for a capacity of 200 kw. The variation in steam pressure was trifling during the tests, and the removal or extraction of steam remained practically constant. The quantity of water entrained during the evaporation was very small —2 to 3 per cent.

Another valuable feature of such an installation is the possibility of utilizing for steam production only the current available at night, storing up the heat in storage boilers. A typical installation works as follows: In the evening when the water turbine of a hydro-electric plant is free to drive the electrical generator, the current produced by the latter is given to the Revel boiler. The steam produced by the Revel boiler is carried by piping into the water contained in the steam storage boilers where it is condensed, thus heating and super-heating the water. The storage boilers are built for 180 pounds per square inch working pressure and 270 pounds per square inch test pressure and are insulated with a double cover of insulated stones. During the night the temperature of the steam storage boilers gets higher and higher, as does the steam pressure and the level of the water. The Revel boiler itself is kept under a constant working pressure of about 165 pounds per square inch by means of a simple automatic device. In the morning the storage boilers are filled up under high pressure and are ready to give steam. The Revel boilers is then disconnected, so that the water turbine may do its day's work by driving the main transmission shaft of the plant. The steam consumption required by the plant is provided during the whole day by the steam taken from the storage boilers. This daily running of the installation is called the discharge of the storage boilers. At noon the discharge may be interrupted by a short recharging. In the afternoon the discharge is continued, and in the evening the cycle is repeated.—E. G. Constam-Gull, *Canadian Engineer*, August 12, 1920; also *Power*, October 12, 1920.

Other references: (1) Boselli, Storage of heat in electrically-heated boilers.—*Ellettrotecnica*, June 25, 1920.

The efficiency of the installation would depend upon the heat radiated from the boilers between the period of accumulation and that of discharge. The author estimates that the heat radiated could be reduced to 15 kg. col. per hour per degree of difference of temperature between the boiler and the air.

(2) On the utility of adding energy accumulators to hydro-electric plants.—*Revue Générale de l'Electricité*, October 23, 1920.

MAGNESIUM

The apparatus used in the production of magnesium is not very different from that used in aluminum and consists of a cell in which anhydrous magnesium chloride is kept in a state of fusion, using a direct-current. After the chloride is molten, the electrolytic action then separates the elements, and metallic magnesium is deposited at the cathode in a molten condition. The reaction involved is simply the dissociation of the chlorine and magnesium by means of electric current. This requires approximately 25 kw.-hr. per pound of metallic magnesium. The character of this load is of course very

uniform and steady, and is in all respects similar to any other electrolytic load. The industry being new, and the process intricate, many improvements are possible in the apparatus for producing this metal.

The tensile strength of magnesium is about twice that of aluminum, and the field offered for expansion is now in the manufacture of magnesium alloys, where light, strong material is needed. It is claimed that these alloys are very easy to turn, thread, file or polish, and that they are not easily attacked by dilute acids, as is ordinary aluminum, and keep their polish better in the atmosphere than aluminum. It is not at all impossible that, due to these very favorable characteristics, when the process is so improved that the cost of production is somewhere near aluminum, this metal will replace the aluminum-copper alloys now used in vacuum cleaners, automobile parts, typewriter frames, crank-cases, etc.

A very promising application of aluminum magnesium alloy is for hydraulic valves and fittings, as well as for certain electrical fittings which formerly have been made of brass and bronze. An alloy containing 96 per cent of aluminum, 2 per cent of magnesium and 2 per cent copper costs about one-half as much per unit of volume as brass. It can be readily seen, therefore, that where requirements are such that strength is of more importance than current-carrying capacity, there are many places where this alloy will be used to replace brass. The future development of the magnesium industry will be around cheap water power. This is because the reduction of magnesium requires such a large amount of power per pound and is one of the largest factors in the cost of manufacturing this metal.—C. A. Winder, Proceedings of the *National Electric Light Association*, May, 1920.

HALF-WAVE AND QUARTER-WAVE TRANSMISSION LINES

A NUMBER of contributions have appeared in the French technical press discussing the possibilities of transmission lines which are electrically a quarter-wave or half-wave in length. In *Revue Générale de l'Electricité* for March 20, 1920, Mr. P. Bunet states that we are at present limited to transmission lines of about 500 km. at a pressure of 100,000 volts per phase. Much longer transmission lines would require a considerable increase of pressure at the beginning of the line in order to take care of the voltage drop and keep the pressure constant at the end of the line. As the inductance and capacity of the line vary with the diameter, no improvement can be obtained by increasing the size of the wires. The author then shows that a line electrically a quarter-wave in length allows the transmission of power to greater distances. Such a line is resonant to the frequency employed, so that for each particular length of line a definite frequency should be employed. Thus, with the ordinary aerial lines the frequency of 50 should be used for a distance of 1,500 km. and the frequency of 25 for a distance of 3,000 km. If the resistance of the line were zero, the pressure at the end of the line would be rigorously constant, if fed at the beginning at rigorously constant current intensity. In practice the resistance of the line necessitates adjusting the current intensity at its beginning, but, because of the resonance, no voltage drop will be caused either by the inductance or by the capacity of the line. The power factor of the energy-utilizing apparatus has no influence upon the regulation of such intensity. Taking a concrete example of a line 1,200 km. long, fed at 50 periods per second, transmitting 75,000 kw. at 100,000 volts per phase at end, the author shows that the current intensity at the departure extremity must vary from 265 to 295 amps. between no load and maximum load; the efficiency between half load and full load is practically constant—about 82 per cent.

The main disadvantage of such a system consists in the necessity of using constant current alternators which have not been yet been studied and constructed. Therefore, Mr. E. Brylinki proposes (*Comptes Rendus*, for April 19, 1920; also *Bull. de. la Soc. Franç Élect* for May, 1920) the use of lines half a wave long for which the usual type of alternator can be used. In these lines the electricity takes half a period to flow from one end of the line to the other. For a frequency of 50 this corresponds to a length of about 3000 km. This length may be diminished by inserting coils, and thus increasing the inductance, or by inserting stretches of buried insulated cable, thus increasing the capacity. The author also gives practical examples of applications of half-wave transmission lines.

ELECTRICAL DEHYDRATION OF OIL

IN order to be salable, or classed as "pipe line" oil and accepted by the transporting companies, a crude oil must contain no more than 2 per cent water. That the necessary process of dehydration can be accomplished by electricity with remarkable efficiency and economy has been shown in recent contributions on this subject.

Mr. J. L. Sherrick writing in the *Journal of Industrial and Engineering Chemistry* for February, 1920, on Oil-field Emulsion, gives a brief review of the development of electrical dehydration. The pioneer patent in the electrical treatment of oil-field emulsions was taken out by F. G. Cottrell (U. S. patent 87115). This process depends for the demulsification upon the action of high potential alternating current electricity. The water is dispersed as finely divided globules throughout the oils and these are caused to coalesce by the action of electrostatic forces. The Petroleum Rectifying Company of California, operating under this and other patents, has installed a number of plants in California, Oklahoma and Kansas.

Another process consists in passing the emulsion between electrodes connected to a source of direct current with a potential of 250 to 400 volts, with a current varying from a few milli-amperes to ten amperes. The patent under which the direct current electrical treatment is operated (U. S. patent No. 1,290,369) claims that the process depends upon cataphoresis on electrical migration. Here may also be mentioned the patents of McKibben (U. S. patent No. 1,299,589 and No. 1,299,590 of 1919) who passes the emulsion of petroleum and water, heated sufficiently to produce vaporization, through an intensified electrical field. The vapors are condensed and cooled, and the water drops out.

Mr. H. N. Sessions describes in *Journal of Electricity* for October 1, 1919, some installations in the Whittier district. The usual electrical dehydrating plant is made up of four treaters and operates on a single-phase alternating current at a pressure of 11,000 volts. In certain leases where water is very scarce, the water electrically removed from the oil is of considerable value. Due to the condenser effect caused by the highly charged electrodes the electric dehydrator operates at about 98 per cent leading power factor. The advantages of electrical dehydration may be summarized as follows: The electrical process leaves the oil its natural color, while the heating process impairs its market value by discoloring it; the heating process requires close watching, the electric practically none. The low fire hazard with electricity is also important. The electric dehydrator effectively treats oils of different grades at the same time without in any way impairing their efficiency. Oil containing eighty-five per cent emulsion has been successfully dehydrated electrically. The electric process causes practically no loss of gasoline, and the records show that after treatment the gravity of the oil has been raised from one to two degrees and has in consequence an increased market value. A record run of 7,000 barrels of the same grade of crude oil was made, first by the heating process, then by the electrical. Eighteen hours was required with heat and only 7.5 hours with electricity, the net amount of the oil being 5,060 barrels with the former process and 5,160 with the latter. The total cost by the heat process for the run was $387 or 7½ cents per barrel, while the entire expense with electricity, even including a royalty of half a cent per barrel, was $102, or slightly less than 2 cents per barrel.

CONSTRUCTION OF THERMO-COUPLES BY ELECTRODEPOSITION

ALTHOUGH thermo-electric appliances have been used in one form or another for nearly a century, the method of constructing these remained practically unaltered—namely, joining together with solder two metals suitably related to one another in the thermo-electric series.

In practice this method has several serious drawbacks which may be briefly stated as follows: (1) It is difficult to form reliable joints between dissimilar metals which will withstand working at high temperatures without deterioration. (2) The maximum working temperature is determined by the melting point of the solder. (3) Owing to the extreme difficulty in making such joints between very small wires it is impossible to reduce the mass of the metal at the points to the extent which is necessary for some special purposes. (4) The labor and difficulty of constructing a large number of junctions to operate in series is excessive; it becomes impracticable when the size of the wires is small.

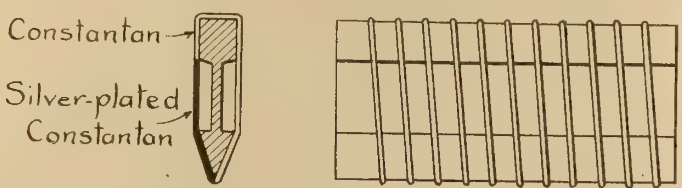


FIG. 1

The new method which was devised to overcome the above mentioned drawbacks consists in using a continuous wire of one of the elements and coating those parts of it which have to form the other element with an electrolytic deposit of another metal. If the conductivity of the latter is considerably greater than of the former, and a fairly thick sheath is deposited, a thermo-couple is produced which is not appreciably impaired in efficiency by the short-circuiting effect of the core. Constantan wires coated with either copper or silver sheath were found to be suitable for most purposes.

For a line of junctions the arrangement shown in Fig. 1 was found satisfactory. In this the core was of ebonite, hollowed out to facilitate cooling, and the conductor consisted of silver-plated constantan strip about 0.008 inch by 0.00075 inch. Sixty junctions had a resistance of 85 ohms. Mica was found more convenient than ebonite for many purposes; however, the presence of any insulating material near the hot junctions materially lowered their temperature, besides rendering their action more sluggish. The arrangement for mounting the junctions shown in Fig. 2 was therefore adopted, whereby the proximity of insulating material to the junctions is avoided.

Another useful arrangement consists of two lines of junctions connected in opposition and arranged close together as shown in Fig. 3. Since the number of junctions in each line may be made large, the deflection of the galvanometer G may be made substantially proportional to the movement of the band of radiant heat. The arrangement, therefore, comprises a useful means of magnifying small movements.

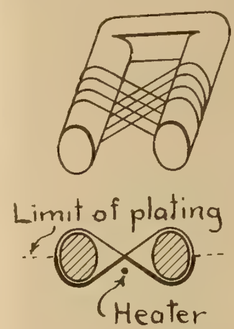


FIG. 2

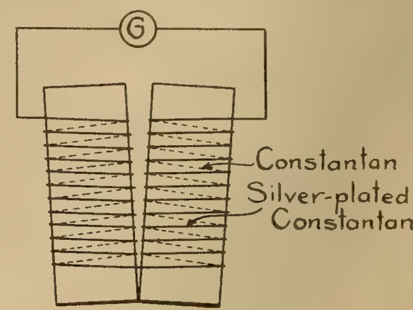


FIG. 3

In the discussion it was brought out that there were many cases in which this device would be of greatest service to physicists, in the measurement of radiation, for instance. It was mentioned that Prof. Hill, of Cambridge, has recently been measuring the rise of temperature of nerves in action by means of these couples. It was also suggested that the method might enable a radiation pyrometer, similar to the Féry type, to be made for the measurement of low surface temperatures. The device is also useful for spectro-radiation work, as the total breadth could be made very small and a large number of junctions per centimeter employed.—Wm. H. Wilson and Miss T. D. Epps, *Proceedings of the Physical Society of London*, August 15, 1920, v. 32, p. 326-40.

Survey of Progress in Mechanical Engineering

Prepared Under the Auspices of the American Society of Mechanical Engineers

THE ULTRA-MICROMETER

BY PROF. R. WHIDDINGTON

NOT so long ago working "to a hair's breadth" was considered quite an achievement. Then, the thousandth of an inch became a fairly common limit of precision in machine work, and a thousandth of an inch is only a fraction of a hair's breadth. It had been found, however, that in order to permit work to a thousandth of an inch the gages had to be made far more precise, and various methods, in particular the so-called interferometer methods of measurement, were developed, permitting a precision as high as one-millionth of an inch.

Interferometer methods, however, are limited in accuracy of measurement by the wave lengths of light used in the production of the fringes. It is not always easy to see at once where precision of measurement in excess of a millionth of an inch may be required, but in scientific work there are already cases where a higher precision is desirable. The ultra-micrometer, a new device, permits measurement to the scarcely creditable precision of one-two hundredth of a millionth of an inch. As an idea of what one-two hundredth of a millionth part of an inch means, it may be said that it bears very roughly the same relation to one inch that one inch bears to the distance by rail between New York and San Francisco.

The new measuring apparatus is based on the fact that if an electric circuit, consisting of a parallel-plate condenser and inductance, be maintained in oscillation by means of a thermionic valve, a small change in distance between the plates produces a change in the frequency of the oscillations which can be accurately determined by certain methods. The sensitiveness of the apparatus is extremely high.

The theory of the method is comparatively simple. If a capacity C be connected to an inductance L, the frequency of oscillation N natural to the circuit is given by

$$N = \frac{1}{2\pi\sqrt{LC}}$$

If the condenser be composed of two parallel plates of area A separated by distance x, then the capacity C is determined by the equation

$$C = \frac{A}{4\pi x}$$

If we substitute this value C into the above equation for N, we obtain

$$N = \left(\frac{x}{\pi LA} \right)^{1/2}$$

which shows that a change in distance x between the plates produces a change in the frequency of oscillations N, so that

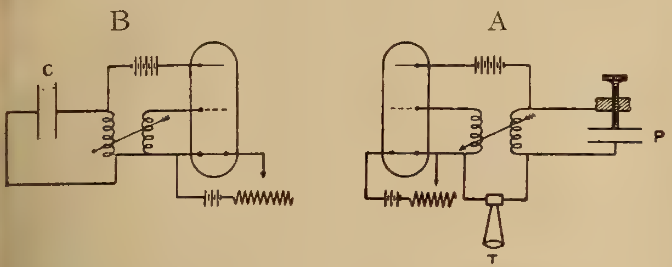


FIG. 1. DIAGRAM OF MAIN ELECTRICAL ELEMENTS IN THE WHIDDINGTON ULTRA-MICROMETER

inversely a change N may be taken as an indication of a change in x.

On the basis of this theory was built the apparatus shown in Fig. 1. In this diagram A is the oscillating valve circuit involving a parallel-plate condenser P; T is a loud-speaking telephone, shown for simplicity directly inserted in the valve-anode circuit, although in actual practice an amplifier intervenes.

The values of the coils in the grid and anode circuits of the thermionic valve were so chosen as to produce oscillations N of about a million frequency. In order to bring about any change in N a second valve circuit B was set up close to the circuit A. The frequency of this circuit could be adjusted by means of the condenser C so as to be nearly but not quite equal to N. This produced a loud audible note in T, the frequency of which could be adjusted to any desired value by a suitable choice of C. Another valve circuit was provided with proper capacities and inductance in order to provide a constant standard of pitch to which the note in T could be adjusted. This additional circuit is now shown in Fig. 1.

As regards the sensitiveness of the apparatus, it may be mentioned that the bending of a very substantial table, produced by an English penny coin laid on its edge, was clearly indicated by a change in the note from the telephone T.

The details of the method of measuring are not given. The method has been of service, however, by proving that Hooke's law was obeyed to the limits of accuracy set by a micrometer capable of measuring to 10^{-4} inch.—*London, Edinburgh and Dublin Philosophical Magazine and Journal of Science*, Vol. 40, No. 239, Nov., 1920, pp. 634-639.

HELICAL SPRINGS

By W. Norman Thomas

It has been observed that in practice many springs fail under smaller loads than those for which they were originally designed. Investigation shows that there are two considerations which may easily be overlooked in the design and use of a spring, namely, (1) the effect of eccentricity of the load, and (2) the effect of the direct shear stress as distinct from the torsional shear stress in the material of the spring. Failure may be due either to entirely overlooking these two points, or, more often, to underestimation of the magnitude of the applied loads and of the effects of impact and repetition of stress. In a considerable number of cases failure may be due to the fact that the springs were designed for normal-temperature work and then afterward employed under very high- or very low-temperature conditions.

Equations are developed for the design of close-coiled springs and open-coiled helical springs, and curves are given, among other things, showing the bending and twisting moments in various parts of springs for different eccentricities of load, and the maximum principal stress and the maximum shear stress at the extremities of the vertical diameter of the cross-section of the wire. From these equations it appears that for the same value of M (eccentricity) the deflection is smaller with an open-coiled spring than a close-coiled spring containing the same length of wire. If the number of coils is the same for each spring, then for the same value of M the deflection is greater with an open-coiled spring than with a close-coiled spring. In addition to this, the values of the stresses in the wire calculated by the various formulae given in the article are tabulated and plotted in Fig. 2. From these it would appear that unless the load is axially applied upon a spring, the stresses may be considerably greater than those for which the spring was designed.

Thus, in an example worked out in the original article, 665 W would represent the load for which the spring was probably designed, that is, assuming axial loading and neglecting the direct shear stress, whereas the maximum shear stress even with axial loading is 721 W, and the maximum principal stress f_2 is 779 W.

With an eccentricity of 0.5 R, which could easily occur, the maximum shear stress is about 1053 W and the maximum principal stress f_1 about 1168 W.

If the eccentricity of the load is greater than 0.5 R the stresses are still more in excess of the nominal safe load for axial loading. It is very important, therefore, that the ends of springs should be so designed as to insure axial loading. This is moderately simple for tension springs, but compression springs present more difficulty; unfortunately, too, the deformation of a spring under an eccentric compressive load tends to increase the eccentricity, and therefore still further to increase the stresses.

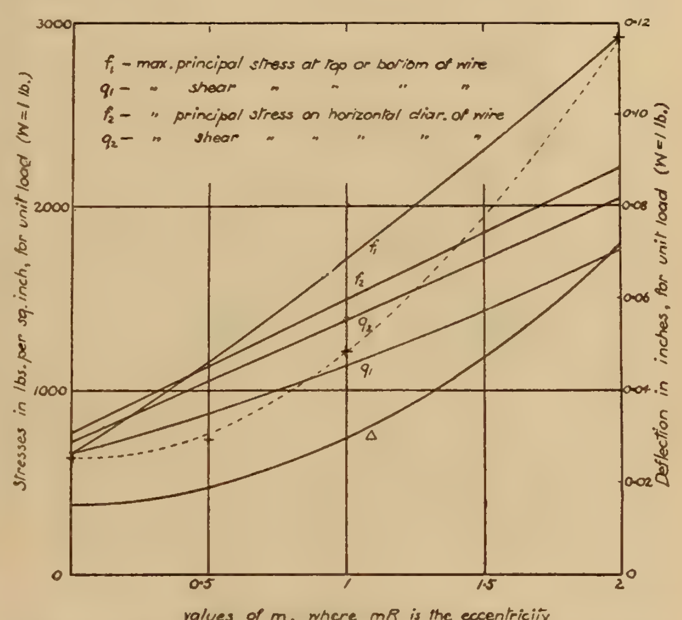


FIG. 2. GRAPHS OF STRESSES IN THE WIRE OF HELICAL SPRINGS CALCULATED BY VARIOUS FORMULAS

Some experiments were undertaken in order to test the truth of the general formula for deflection obtained in the original article, and they have generally confirmed it.—*Journal of The Institution of Mechanical Engineers*, No. 7, Nov., 1920, pp. 869-889.

WIRE ROPES RESEARCH

Report has been issued by a Committee of the Institution of Mechanical Engineers covering experimental research on wire ropes for use over pulleys.

It does not appear that the committee carried out any special experimental work of its own, but it very carefully collated all the available information and presented it in a clear form.

The conclusions arrived at are that there is no reliable information available as regards the factor of safety when used over pulleys. No sufficient data are available to estab-

lish a general method for the design of ropes, especially as entirely different problems present themselves in various installations. Thus, the outside wear is most important for a rope working on a large pulley, whereas bending fatigue and internal wear do most damage when a small sheave is used.

The calculation of the bending stress for design does not at present appear to be satisfactory. There is a lack of agreement on the factor to be used with the Reuleaux formula. There is no rational formula which covers the actual conditions and it has not yet been shown that the bending stress is the determining factor in the destruction of a rope. It is suggested that an attempt should be made at an analysis which will separate the three destructive effects: namely, outside wear, wear between the wires, and bending fatigue.

Distinction should be drawn between hardness and tensile strength, which are generally regarded as increasing together.

The information concerning the wire diameter indicates a difference of opinion which was not expected. As regards the adjustment of the lays to suit the diameter of the pulley, some writers have asked for it, but there is no exact information which bears on this point. The balance of opinion favors Lang's lay, where it can be used, but the preference is not shown so clearly by American engineers.

The effect of different angles of bending of the cable over

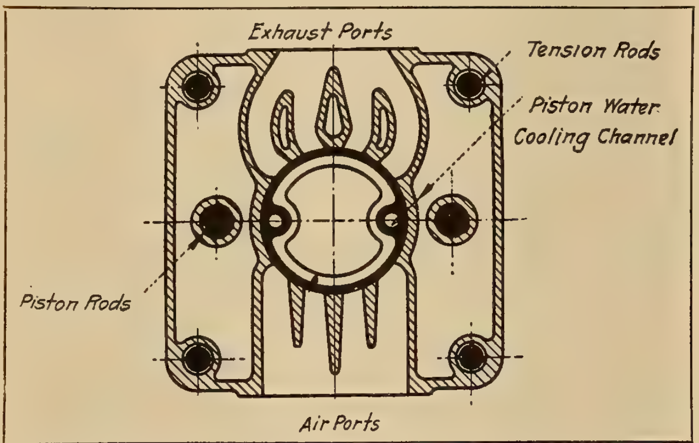


FIG. 3. SECTION THROUGH POWER CYLINDER OF THE MANNING, MAXWELL & MOORE MARINE DIESEL ENGINE

the pulley appears to be explained very clearly by Leffler, although some opinions are at variance with his conclusion. The formula he gives to calculate the true radius of curvature of the rope does not agree with that of the Trenton Iron Company.

The report points out the scarcity of experimental data and gives the impression as if in the field of wire rope for use over pulleys, there is scarcely a single element of design on which sufficient information is available and an agreement exists between engineers. To say the least, this is a very surprising state of things considering the extensive and long use of such wire ropes.—*The Journal of the Institution of Mechanical Engineers*, No. 7, Nov., 1920, pp. 835-868.

GOLDBERG DOUBLE-ACTING TWO-CYCLE MARINE DIESEL ENGINE

DESCRIPTION of an engine in which the scavenging pump is in two stages, the first stage serving for scavenging proper and the second stage for supercharging the working cylinder and also as the first stage for the injection-air compressor. With this arrangement the low-pressure injection cylinder requires not over 70 per cent over its displacement when using air at atmospheric pressure. The air-pump piston closes the scavenging ports ahead of its dead center for a distance, preventing the pump on its return stroke to fill again from the working cylinder.

This means that the scavenging port of the pump cylinder is not uncovered again until the working piston has covered the scavenging ports of the power cylinder.

To provide a better cooling of the pistons, the piston rods are extended into the upper cylinders and are drilled as shown in Fig. 3, one rod serving for water intake and the other for water outlet. The stuffing boxes proper for these sliding pipes (Fig. 4) consist of a light tubing with a collar at the bottom extending to the lower end of the cylinder casting. The packing is held between the lower collar and the gland in the form of a tube.

It is claimed that the double-piston-rod arrangement besides other advantages accomplishes also a great saving in the construction of the connecting rods. With this, the cross head proper consists of a simple steel forging to which the crosshead shoes are fastened in a conventional way, but the forked type of marine rod is not used any more.

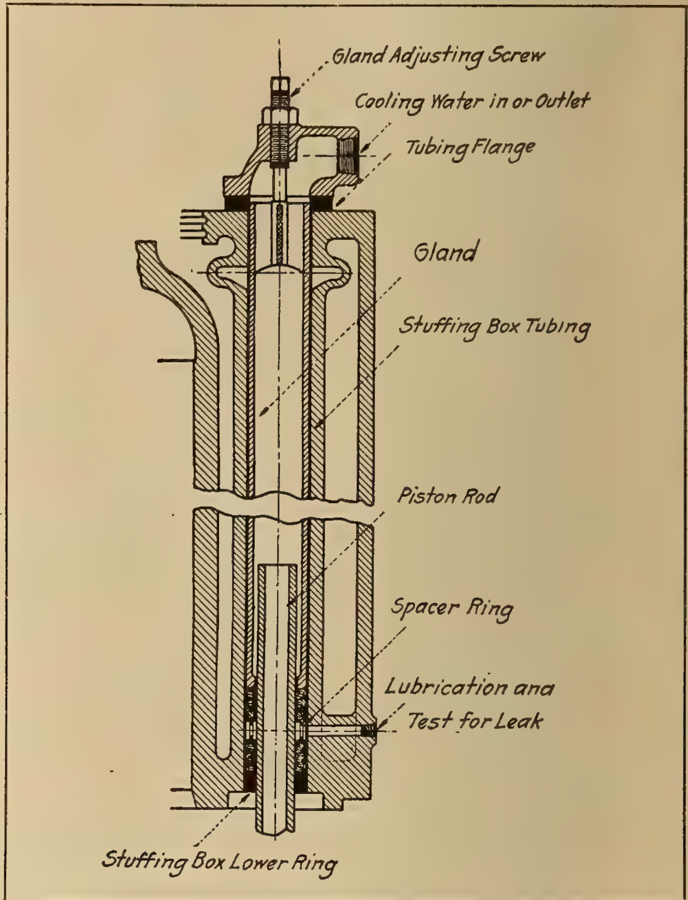


FIG. 4. A LARGE SECTION OF STUFFING BOX FOR PISTON-COOLING ARRANGEMENT, MANNING, MAXWELL & MOORE MARINE DIESEL ENGINE

The four-cylinder 3,000-shaft hp. engine of this type has the following dimensions:

Bore	22 in.
Stroke	33 in.
Speed	120 r.p.m.
Piston speed	660 ft. per min.
Shaft mean effective pressure (m.e.p.)	66 lb. per sq. in.
Overall length, including flywheel, thrust block and air compressor	40 ft.
Overall height from center line of shaft	26 ft.

A shaft m.e.p. of 66 lb. per sq. in. is a very conservative figure. The low-piston speed of 600 ft. per min. was selected with propeller efficiency in view. A shaft m.e.p. of 66 lb. per sq. in. can be obtained without surcharging the cylinders and the great overload capacity of this type of engine for forced runs of vessels may well be of great value. With surcharging and increasing the speed of this engine, say, to about 160 r.p.m., we can obtain 3,000 shaft hp. for short periods, though it may not be advisable to carry this load through continuous days of service.—*Motorship*, Vol. 5, No. 11, Nov., 1920, pp. 993-994.

Progress in Mining and Metallurgy

Abstracts of Papers and Recent Articles

Prepared Under the Auspices of the American Institute of Mining and Metallurgical Engineers

SEALING OF WATER HORIZONS IN OIL WELLS BY MEANS OF CEMENTING PROCESS

By A. A. Downs

There are few oil fields that have no water problem peculiar to themselves, and still fewer without water horizons in the strata to be penetrated in the search for petroleum. Many promising areas have been ruined by careless exploitation without proper care to exclude water encountered from the bore hole, and in most countries special legislation has been enacted to ensure the protection of oil horizons from water encroachment by way of the wells drilled. In established fields, the levels at which water may be expected are known, and the wells are drilled with a view to carrying the water string of pipe to the correct depth, where the operation of cementing is carried out. The plant required for this operation consists of a string of steel tubing long enough to reach to the bottom of the well, and generally 3 inches in diameter, and a high-powered force pump together with the necessary connections. The pumps are generally of the duplex type and constructed to handle heavy muddy fluids efficiently. Most operators prefer to have two pumps on hand, as even a short stoppage may be fatal to the success of the job, and even damage the well. The size of the pump depends on the amount of cement to be used and the depth of the well, and often on the condition of the latter, but generally speaking it should be capable of exerting a pressure of 700 pounds, and putting through 50 barrels of cementing fluid in half an hour.

In Fig. 1 all connections are shown in place and all essential parts are indexed. The first essential in determining whether the well is in right condition for cementing is to have the pipe to be cemented perfectly free in the well, so that it can be lifted and lowered without difficulty. The pipe should be tested several times by lowering it and raising it several feet. All being in order, the tubing is put in and the well head connected to the pump. The pump is started on water, which passes through the tubing to the bottom of the well and up to the surface on the outside of the pipe, to make more certain that the pipe is free and to wash away small obstructions; the pipe is tested while this is going on. The cement is then quickly mixed, the fluid being made quite thin and as easy as possible to handle with the pump. At the time of starting the cement into the well the casing should be about 18 inches from the bottom of the well; the water is cut off and the cement mixture taking its place is forced into the well as fast as possible.

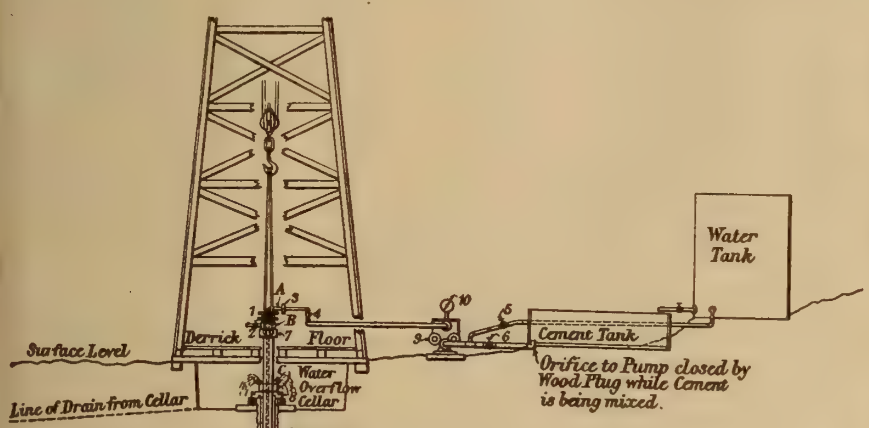
The strata at the bottom of a hypothetical well are represented in Fig. 2, which shows the position of the pipes and tubing and the cement below and behind the pipe, at this stage of the operation.

The well is left for about a month, to allow the cement to set. When drilling is again started, a certain amount of set cement will be found inside the pipe, but this is easily drilled out in the usual manner.—Abstracted from *Engineering*, London, November 5, 1920, pp. 596 to 598.

BY-PRODUCT EXPANSION IN NON-METALLIC MINERAL INDUSTRIES

By Oliver Bowles, Washington, D. C.

It is estimated that the value of the raw materials in the non-metallic minerals exclusive of coal, oil, gas and related minerals, produced in 1919, together with certain of the primary products ordinarily manufactured at the mine, exceeded $800,000,000. In many of the producing industries of this great group, the waste is so great that the expense of handling is an important item in the production cost. The utilization of waste is receiving unusual attention in many of the non-metallic industries at present.



1 Split gland stuffing-box, quickly removable.
2 Relief-valve.
3 Quick disconnecting joint.
4 Swing joint or flexible pipe.

5 Water-gate valve.
6 Cement-gate valve.
A. A. = tubing.
B. B. = pipe to be cemented.
Supported on :—
7 = elevators on slings ready to lower.

C. C. = Next outer pipe to B. B. on :—
8 = Casing clamps.
9 = Pump.
10 = Pressure-gauge.

FIG. 1. WELL HEAD CONNECTIONS USED FOR TUBING METHOD OF CEMENTING

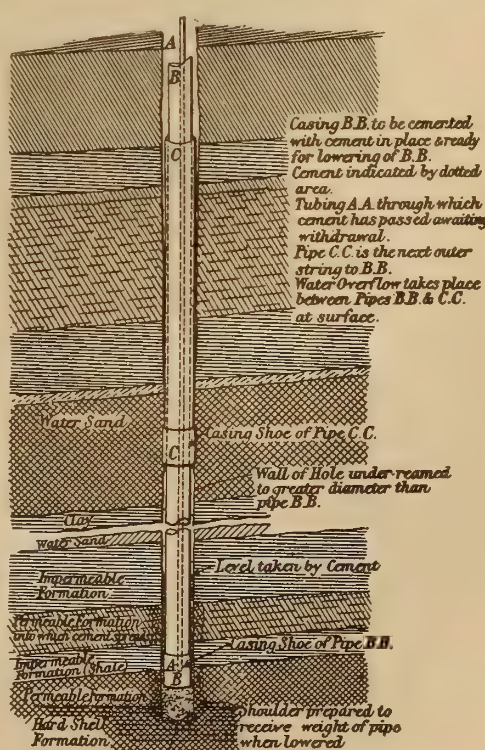


FIG. 2. SECTION OF THE BOTTOM OF A WELL

The recent development of various types of artificial roofing has adversely affected the slate industry. The proportion of waste is high, in some places exceeding 90 per cent of gross production. The North Wales Development Co., Ltd., of Bethesda, Wales, has developed a series of waste slate by-products. The waste is said to have been used satisfactorily for the manufacture of pottery and tiles. Waste slate is also pulverized and used as a filler in abrasive soaps, rubber, asphalt, paint, flooring, etc. The most important by-product is brick, the present production of which is about 10,000 per day.

In the granite industry there is considerable waste, particularly in monumental granite areas where the proportion of waste is almost as high as in slate quarries. As crushed granite is an excellent road material, the enlarged program of highway construction offers a promising outlet.

In the mica industry, waste is utilized in the manufacture of ground mica. There is, however, the possibility of by-product development in the mining process. Mica occurs in pegmatites, which consist chiefly of feldspar and quartz; possibly much of this feldspar could be utilized in the ceramic industries.

Waste marble is used to some extent for rip rap, for terazzo flooring, and for agricultural purposes. The latter use could be greatly extended. Marble waste is also pulverized and sold as marble flour; for certain purposes, this has been successfully substituted for imported whiting. In an attempt to discover profitable uses for small pieces of marble, two companies, independently, have recently experimented with a process of facing concrete blocks with slabs of marble too small for other structural uses; their method gives promise of practical results. A fluorspar company, in Illinois, recovers calcite from the jig tailings and pulverizes it for agricultural limestone.

In the talc industry, waste could be utilized in manufacturing. While nearly all the off-color and impure talc now mined in the United States is wasted, in South Africa and Germany such materials are manufactured into special products, which, with the stimulation of an advertising campaign, have found a ready market.—To be presented at New York Meeting, February 14-17, 1921.

THERMAL EXPANSION OF COPPER AND ITS IMPORTANT INDUSTRIAL ALLOYS

By PETER HIDNERT, Washington, D. C.

DATA on the thermal expansion of 128 samples of copper and its important alloys of various compositions, heat treatments, mechanical treatments, etc., are presented. The specimens contained from 56 to 100 per cent copper and were prepared in a number of ways—cast, cast and cold rolled, extruded, extruded and cold worked, hot rolled and cold worked. Most of the samples were examined from room temperature to about 300° C. (Several specimens were cooled to —50° C. and then heated to + 300° C.)

Practically all available information on the thermal expansion of copper and its alloys is briefly reviewed. A description of the apparatus and the preparation of the samples, etc., is given.

Definite mathematical relations were found to exist between the coefficients of expansion and the copper content of most of the alloys investigated. In general, the coefficient of expansion increases with a decrease in the copper content. The addition of lead or tin has a decided effect on the coefficient; the former element generally decreases, and the latter increases the coefficient.

In the case of alloys containing 62 per cent copper, it was found that the coefficients did not materially differ in cast or cold-rolled specimens, and for alloys containing 90 per cent copper, a similar agreement existed. For alloys with a copper content from about 62 to 90 per cent, the cold-rolled alloys have greater coefficients than the castings, and for alloys containing more than 90 per cent copper, the reverse is true. The coefficients of the inside sections of the castings are generally slightly less than those of the outside sections. A relation exists between the density and thermal expansion of the cold-rolled copper zinc alloys.

The coefficients of the cold-rolled tin alloys are less than those of the castings. Cold rolling and drawing, therefore, cause a diminution in the values of the coefficients.

Owing to the large number of varying elements in the hot-rolled and extruded samples, it was impossible to determine the exact effect of each constituent element. In general, however, the coefficients are greater than the extrapolated values obtained from the quadratic equations of the copper-zinc alloys, showing a tendency toward increasing values as impurities are added.

The differences between the various series of samples are discussed and presented graphically.—To be presented at New York Meeting, February 14-17, 1921. This paper will not be printed in full by the Institute.

POTASH IN NEW JERSEY GREENSANDS

By GEORGE ROGERS MANSFIELD, Washington, D. C.

THE United States Geological Survey, in coöperation with the New Jersey Department of Conservation and Development, in 1918-19 explored the greensand beds of New Jersey as a source of potash. Here potash occurs chiefly in the mineral glauconite, which imparts to the greensand its characteristic color. The only glauconite-bearing formations of commercial importance in New Jersey, which, from present data, are also the richest in the country, are in ascending order the Navesink, Hornerstown, and Manasquan marls of Upper Cretaceous age. The Navesink and Hornerstown are separated from each other toward the northeast by the Red Bank sand and the Hornerstown and Manasquan are separated by the Vincentown sand, important locally as a water-bearer and as a source of lime.

Preliminary examination showed that drilling would be necessary; 19 holes were sunk, ranging in depth from 9 to 70 feet, and averaging 37 feet. A series of continuous samples of material from top to bottom was obtained at most of the holes. The data from borings were supplemented by well and field data on file in the office of the New Jersey Department of Conservation and Development. Five type areas of 2½ acres each were made the basis of specific estimates; these were at Salem and Woodstown, Salem County, Sewell, Gloucester County, Somerdale, Camden County, and Marlton, Burlington County. At Sewell, three greensand beds of commercial quality and thickness have been recognized, which are generally distinguishable throughout the region where borings were made. These are respectively gray or bank marl, green and chocolate marl.

It is conservatively estimated that the New Jersey greensands contain 256,953,000 short tons of potash K_2O that could be mined by open-pit methods. At the rate of importation for the five years preceding the war, including 1914, this quantity could supply the needs of the United States for nearly 1000 years. Should it become practicable to use underground methods of mining, the available quantity of potash would be enormously increased.

Four companies have undertaken to produce potash from New Jersey greensand. Small quantities of potash have been made and sold but no activity on a commercial scale has yet been reported. The first two produce potash in the form of chloride without by-products. The third aims to utilize the entire greensand in fertilizer, having first converted the potash into available form. The fourth produces a caustic potash and a by-product that may be utilized as agricultural lime or in the manufacture of brick or tile. It has under construction a large plant capable of handling 1000 tons of greensand per day at New Brunswick, N. J. In addition, by experiments, a company at Coplay, Pa., using a Cottrell dust-collecting system and greensand in its cement mixture, has demonstrated the feasibility of increasing its output of by-product potash.—To be presented at New York Meeting, February 14-17, 1921.

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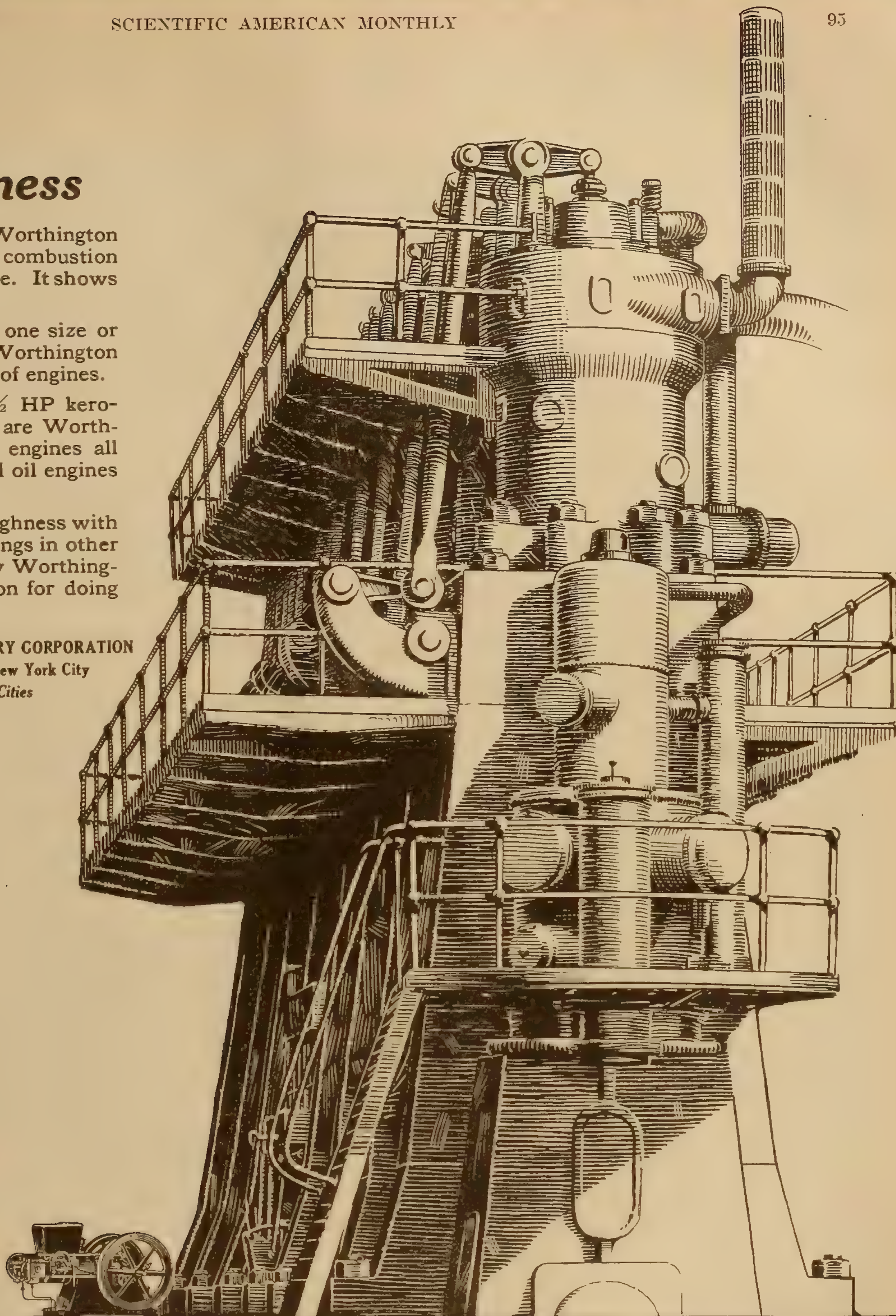

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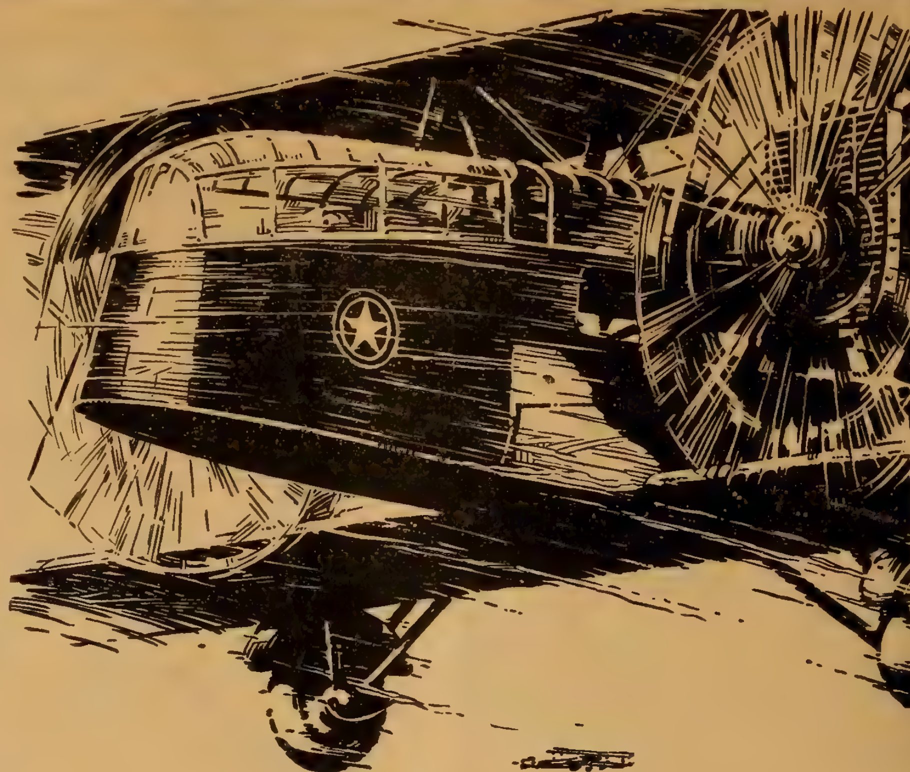

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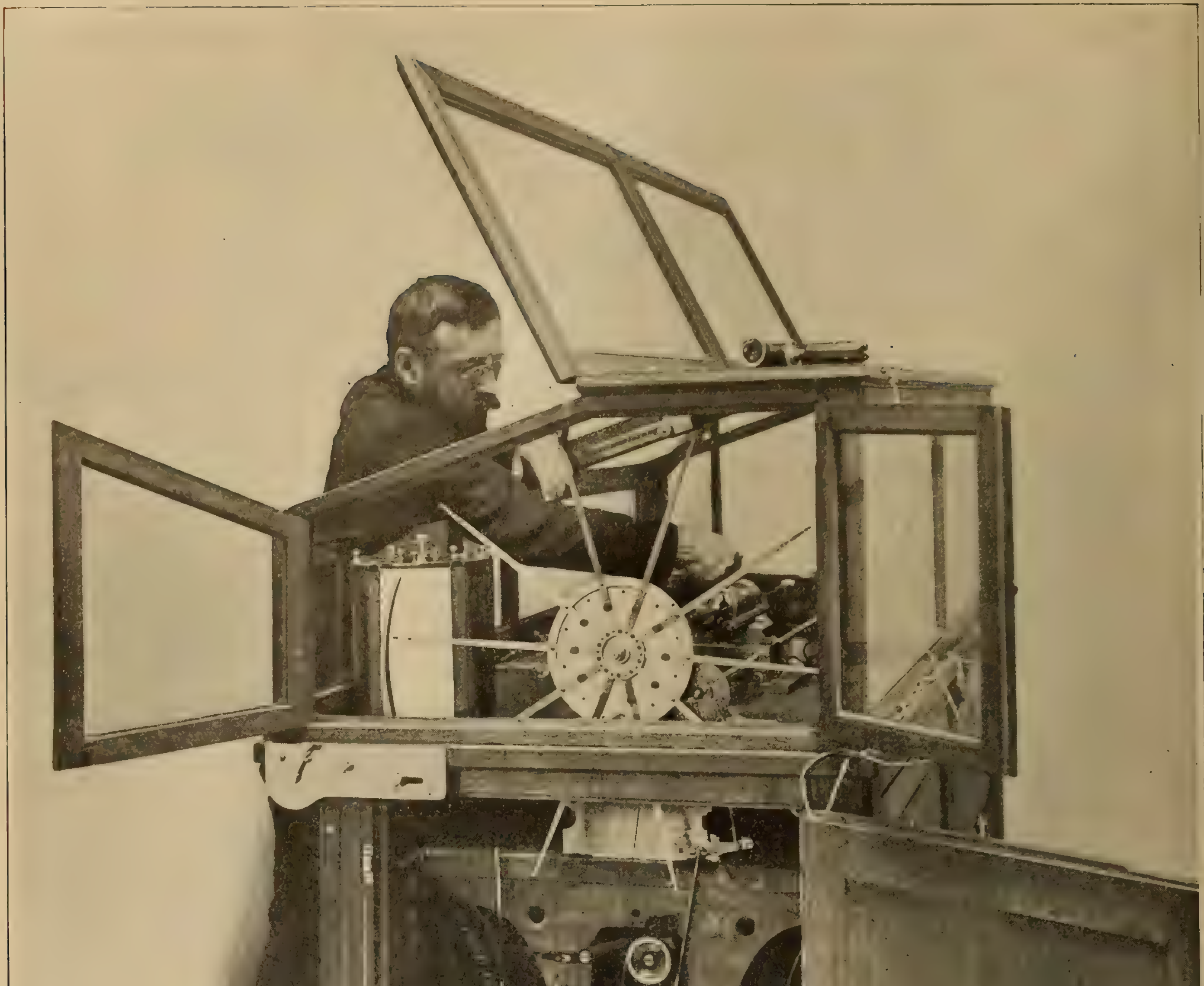

THE INTERNATIONAL BUREAU OF WEIGHTS AND MEASURES—COMPARING END STANDARDS FOR ENGINEERS' MEASUREMENTS WITH THE HARTMANN COMPARATOR (SEE P. 105)

SCIENTIFIC AMERICAN MONTHLY

VOLUME III
NUMBER 2

New York, February, 1921

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THE EINSTEIN AWARD

Our readers will remember that in July of last year Mr. Eugene Higgins offered, through the Scientific American, a prize of the extraordinary amount of $5,000 for the best popular essay on the Einstein Theories of Relativity. The contest aroused wide interest, and a wide response. Essays were received from all parts of Europe and North America, from India and South Africa and South America. When the contest closed on November 1st there were in the hands of the Einstein Prize Essay Editor exactly 300 essays.

With such assistance as it was proper for the Einstein Editor to extend them, the judges, Drs. Leigh Page of Yale and E. P. Adams of Princeton, have since this date been working their way through this mass of material, eliminating essays as fast as possible, and gradually approaching the ultimate goal of a single survivor. This goal has at length been reached; in the issue of the Scientific American which is current when this number of the Monthly goes to its subscribers, the long-looked-for announcement is made that the prize has been won by Mr. L. Bolton, of London. Mr. Bolton's essay will be printed in the Scientific American for February 5th.

The choice of one essay out of 300 at the best is an undertaking which must in large measure reflect the personal taste and the personal opinion of the one who undertakes the choice. With this in mind, it had hardly been our hope that the judges would agree upon a winning essay; we had been quite prepared for the necessity of the Einstein Editor's being called upon to decide between their respective preferences. We need not say that the ability of the judges to agree upon a winning essay without this step has been a source of extreme gratification to us.

It will be understood that the whole purpose of Mr. Higgins in offering this prize, and of the Scientific American in sponsoring the offer, was by no means the elicitation of a single "best" essay. The other 299 essays in their entirety must necessarily make a contribution to the literature of the subject which is second only to that made by the winner, or which might even conceivably be of such value as to make the winning essay second to it. Viewed from the standpoint of the completeness with which the totality of the competing essays covers the field of Relativity the present contest has been a notable success. In variety of treatment and in diversity of material the essays are all that could have been hoped for.

In the Scientific American Monthly for March we shall present one of the essays—the one which is at once the winner's closest competitor and the best suited of the leading dozen essays for a position here in preference to one in the Scientific American itself. This will be followed, in subsequent issues both of the Scientific American and of the Scientific American Monthly, by further essays.

A NEW ASTRONOMICAL MARVEL

Strange as it may seem the largest object ever measured was scaled off with the minutest of measures known to science, and it but adds to the paradox to state that the measurement, while the most stupendous ever undertaken, was at the same time the most infinitesimal. The object which was the star Betelgeuse in the constellation of Orion, turned out to be some three hundred million miles in diameter and the unit of measurement employed was half a wave-length of light.

Now to the vast majority of us, a hundred million miles conveys little meaning and a wave length of light even less. Nor does it help us much to be told that the average solar light wave measures about 0.00002 inch in length. This length is so infinitely small that we cannot begin to visualize it. In former days a hair's breadth was rated as the very acme of tenuity. It is a very fine human hair that measures two one-thousandths of an inch in thickness. Now take that hair and split it into a hundred slivers, and we shall find that each sliver is equal in thickness to the length of a single wave of light. In other words, a ray of light makes one hundred vibrations in traversing a space of the breadth of a fine hair and when we consider that the ray is traveling at a rate of 186,000 miles per second, we must admit that the frequency of these vibrations far surpasses our powers of conception.

However at present we have to deal not with the frequency of the oscillations, but with their length. In fact it is only half a wave-length that is used as our unit of measure; in other words, the one-hundredth part of half a hair's breadth.

Of course it was not the actual diameter of Betelgeuse that was measured, but the minute angle formed between two rays starting from opposite sides of the great star and coming together in our telescope. Just how this angle was measured is explained very clearly by Professor Russell's article in the following pages. The angle worked out to forty-five one-thousandths of a second of arc; in other words, the rays are so nearly parallel that they would not show a spread of a hair's breadth in 250 yards and we should have to travel back along the rays for a distance of over 70 miles before we should reach a separation of one inch. Of course the farther we trace these rays, the greater the separation until eventally we arrive at their source where of course their separation equals the diameter of the star. Hence, if we know the distance of the star from our telescope, we can determine its size.

Unfortunately Betelgeuse is so remote from us that it is exceedingly difficult to measure its distance with any degree of accuracy. According to the latest estimates, it is probably well over 200 light-years distant from us and its diameter must therefore be about 350 times that of the sun.

Measuring the Diameter of the Stars

Recent Astronomical Applications of Professor Michelson's Interferometer

By Henry Norris Russell

Professor of Astronomy at Princeton University

VISITORS to an observatory, who have enjoyed a look at one of the planets, and have seen how large it appears under the magnifying power of the eyepiece, are very likely to ask next to be shown a star, anticipating that it also will appear as a visible disk. When the telescope is turned on a bright star, they are usually much surprised by what they see. The brilliance of a conspicuous star, when its light is concentrated by a large telescope, is spectacular enough to satisfy pretty lively anticipations; but the novice is prone to amazement when he finds that, though it appears so much brighter, the star looks no bigger through the telescope than it does without it. Though its image may be surrounded by more or less "glare" (due to the scattering of light by dust on the lenses, or to minute imperfections in them) the actual image of the star itself is still a mere speck, without perceptible dimensions, though dazzlingly bright.

The trained observer, however, who notices finer details, will see, under a high magnifying power, that the telescopic image of the star is not really a mathematical point, but a tiny circular disk surrounded by concentric luminous rings, separated by dark intervals, and each farther than the last, so that only a few are visible unless the star is very bright. This singular pattern appears of the same size and similar in all its details, whatever be the star upon which the telescope is turned; and this part alone might lead us to suspect that its appearance was due to some property of the telescope, and not of the stars. If our telescope has an iris diaphragm before its objective, we may at once change this suspicion into certainty. As the diaphragm is narrowed, and the clear aperture, through which the star's light enters the telescope is diminished, the pattern of disk and rings will be seen to expand, reaching double its original diameter when the opening of the diaphragm is reduced to half its initial size. This "spurious disk" is not due to any imperfection in the construction or adjustment of the telescope, but arises—as we shall see more fully later—from the very nature of the waves of light. No optical device whatever can get rid of it absolutely, but there is one effective, but very expensive, method of diminishing it, namely, to increase the size of our telescope. The astronomer measures the diameter of this spurious disk, just as he would measure that of a real disk which looked equally big, in seconds of arc; and its diameter, measured in this way, is inversely proportional to the aperture of the telescope. For a clear opening one inch across the spurious disk is 4″.5 in diameter; for a telescopic aperture of one foot, it is 0″.38, for the Yerkes 40-inch telescope 0″.11, and for the 100-inch at Mount Wilson a little less than 0″.05. The "resolving power" of a telescope—that is, its power of revealing minute detail—is therefore proportional to the available aperture of the instrument.

A close double star, in which the components are half a second of arc apart, cannot be seen double with a six-inch telescope, for in such an instrument the spurious disks are 0″.75 in diameter, and overlap one another—though a thoroughly experienced observer might detect that the image formed by the two overlapping disks was slightly oval. With a 12-inch telescope the same pair would be easily separated; but to resolve a closer pair—say, of separation 0″.45—would require an aperture of 30 inches at least. Every increase of aperture reveals new double stars, which were irresolvable in smaller telescopes, and there are doubtless great numbers more of double stars so close that no existing telescope can separate them.

The practical astronomer would however be happy indeed, if no other limitation than the one of which we have been speaking, affected his observations. But, alas, he has to look through fifty turbulent miles of the earth's atmosphere. Even under the best conditions, the rays of light which enter his telescope have been more or less deviated in their courses by refraction in passing from one layer of air to another, and, in consequence, the diffraction pattern of disk and rings, which can be so clearly and beautifully shown in the laboratory, oscillates, trembles, and is more or less confused and distorted. Under more ordinary and worse conditions of "seeing" the image is more disturbed and dances about, coming only occasionally to rest, and it is during these favorable intervals alone that close pairs of stars can be seen double. On many nights, indeed, when the sky is cloudless, but the air windy, and full of streaks of varying density and temperature (the airman's "bumps") the stars twinkle furiously, and their telescopic images are so blurred that accurate observation of any sort is impossible.

Unfortunately, too, a given amount of atmospheric disturbance affects a large telescope much more than a small one, for the large instrument looks through a wider column of air, in which there is greater chance of meeting with optical disturbances. With such an instrument, it is decidedly rare to find a night on which the seeing is really satisfactory—even in those favorable localities which have been chosen as sites for modern observatories.

It is clear from the foregoing how welcome it would be to astronomers to have some way of obtaining a high resolving power other than by building enormous and exceedingly costly telescopes, and also how great a boon it would be to escape, even in part, the annoyances and obstacles which arise from the turbulence of our atmosphere. Professor Michelson's most recent addition to the long list of his notable services to science has been to solve both these problems—and to win his success by the use of those very properties of waves of light which cause the appearance of the annoying spurious disk. The apparatus which he employs—the interferometer—is one which he designed many years ago, and has applied with notable success to the investigation of many other problems.

The fundamental principle which it involves is the separation of a beam of light, proceeding from a single source into two parts, and the recombination of these two beams in such a way that the light waves can "interfere" and produce a visible pattern of light and dark bands, or "fringes."

The manner in which these fringes is produced is the central feature of the whole affair, and is simple enough to understand, if we remember that light consists of "trains of waves in the ether." The light given out from luminous gas, like that in a nebula, consists of very regular and uniform oscillations, which repeat themselves at exactly equal intervals, in time and space, for thousands of successive vibrations. A hot body, such as a star, gives out a jumble of vibrations of all periods. But fortunately for the present purpose our eyes are sensitive only to vibrations including but a small range in period (especially when, as in the case of the stars, the light is fairly faint), so that we may ignore the other vibrations, whether more rapid or slower, and confine ourselves to those which are very near a certain average rapidity of vibration, or length of wave. These "waves" consist of changes in the electrical and magnetic condition of the ether, alternately on opposite sides of the undisturbed state. If then two waves, reaching the same point by different paths arrive so that they disturb the ether at the same instant in the same way (technically, if they arrive with the same phase) they will rein-

force one another, but if they arrive in opposite phases, the disturbances which the two produce will annul one another, and the two waves will "interfere."

In the simplest form of Michelson's recent apparatus, two slits S_1 and S_2 are made in a screen S set up in front of the mirror of a reflecting telescope as is shown in Fig. 1, which is a section of the apparatus at right angles to the direction of the slits.

The waves of light emitted from the star toward which the telescope is pointed are illustrated in the upper part of the figure by lines following successive "wave fronts" (that is, regions where the disturbance in the ether is at a maximum, and in the same phase). These wave fronts are really arcs of circles centered upon the star, but, for all practical purposes, we may treat them as straight. They advance at right angles to the wave front, as is shown by the "rays" R_1 S_1 and R_2 S_2 and impinge upon the two slits S_1 and S_2 at exactly the same instant and in the same phase. Being reflected from the mirror immediately behind they emerge again from the slits,

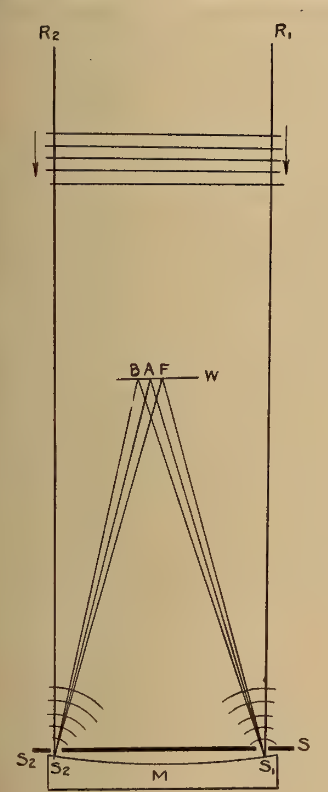


FIG. 1

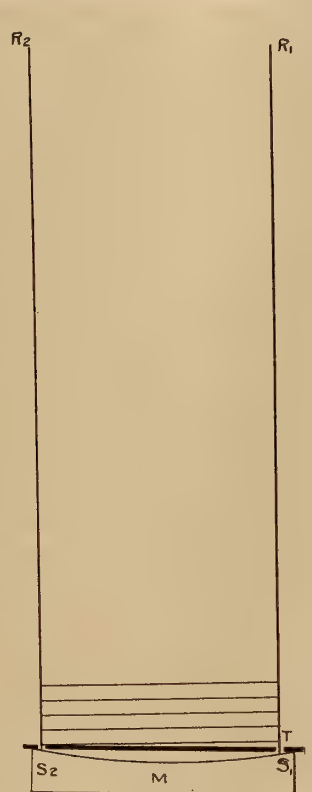


FIG. 2

and, upon escaping from these narrow apertures, they tend to spread out, as illustrated by the circular wave-fronts drawn on the diagram.

If F is the focus of the mirror, the distances F S_1 and F S_2 will be equal and the two reflected waves, which started from S_1 and S_2 at the same instant, will take equal times on the journey and reach F together—and once more in the same phase. They will reinforce one another so that there will be plenty of light at F. If, however, we go sidewise from F to some other point, such as A or B, the distance from S_1 and S_2 will no longer be equal, and the two waves will not arrive at the same time. At some point A the difference of A S_1 and A S_2 will be half a wave-length and the disturbance coming from the nearer slit will be in advance of the other by half a vibration, so that the two will arrive in exactly opposite phases, and their effects will annul one another. Farther out, at B, where one of the two paths exceeds the other by a whole wave length, the first set of waves will have gained a whole vibration on the other and each disturbance from S_1 will meet with the one reflected from S_2 one period later in such a way that the two reinforce one another. Still farther out, where the path difference is 1½ wave-lengths, destructive interference will again occur and so on.

If then we should place a white screen W in the focal plane, we would see on it a bright region at F where the waves reinforce one another, a dark region at A (where they annul one another) a second bright region at B, and so on. In the direction parallel to the slits (and at right angles to the plane of the figure) these bright and dark regions would be drawn out into parallel lines or "fringes," alternately bright and dark.

These are the fringes which are used in the Michelson interferometer. Before proceeding to describe its applications, we may, in passing, use the principles which we have just studied to explain the formation of the spurious disk in an ordinary telescope.

Suppose that a large number of other intermediate slits in addition to S_1 and S_2 were made in the screen S, alternately, the whole screen would be cut away, leaving the mirror free, but in following the interferences of the light waves, we might still divide up the mirror surface into a great number of adjacent parallel strips, such as the slits would isolate.

At the point F the waves reflected from all these "elementary" strips will arrive together, in the same phase, and we will get universal reinforcement and a great deal of light. At A the waves coming from opposite sides of the mirror, at S_1 and S_2 will completely annul one another. The waves coming from paths of elements on each side, but nearer the center will, however, only partially annul one another (being out of phase by less than half a period) so that when all is added together the light, though weakened, will not disappear. But at B there is a difference of a whole wave between S_1 and S_2 and hence of half a wave between S_1 and the light reflected from a strip at the middle of the mirror.

The light reflected from these two strips will then interfere destructively. Similarly for any strip between S_1 and the middle of the mirror it will be possible to find a corresponding strip between the middle and S_2, such that the disturbances reflected from the two arrive in exactly opposite phases. If all the strips of the mirror were of the same length and hence reflected equal amounts of light the contributions of the successive pairs which we have described would annul one another, each for each, and no light at all would be seen at B. When the fact that the strips near the middle are longer than those near the edges is taken into account, it is found that there is still a faint illumination at B, but that the light disappears altogether at a point about twenty per cent farther away from F. Beyond this, though a larger part of the contributions reflected from the various strips cancel one another, there is a small unbalanced residue, and faint light reappears, to be succeeded by other dark regions of complete annulment, and by ever fainter ones of incomplete cancellation.

We would evidently reach a similar result if we went to the same distance from F in any other direction in the plane of the screen W (at right angles to that of the paper). Our interference pattern will therefore be this time a circular disk, surrounded by a dark rim, then by a faint ring of light, and so on—just as is seen in the telescope.

So far, in considering the production of the fringes, we have treated one star as if it were a mere luminous point. It is, however, in the modifications introduced into this simple theory, by considering the actual conditions, that the importance of the new method lies.

Consider first the case of a close double star, too narrow to be resolved by the telescope which is employed. If we point one instrument toward such a system, we will see, with the telescope alone, merely a single spurious disk formed by the superposition of the diffraction patterns of the two stars. Similarly, if we introduce the Michelson apparatus we will have two sets of fringes in view at once, and superposed.

If the telescope is pointed exactly at one star of the pair,

the light waves from this star will arrive at the slits S_1 and S_2 at exactly the same moment, and will produce fringes exactly as described above with the central bright fringe at F.

But the light waves from the other star will come down at a slightly different angle, as illustrated in Fig. 2, and each wave will reach one of the slits, say, S_2, a little earlier than the other. This retardation will be carried over into trains of reflected waves which emerge from the slits. If the difference of path, outside the slits, for the second star is half a wave length, the reflected wave trains will be out of step by half a period, and when they reach the point F, after traversing equal paths from S_1 and S_2, they will be in a condition to interfere, and there will be darkness instead of light at this point. On the contrary, the trains of waves arriving at A will be in phase with one another—the half wave gained on the shorter journey from S_2, combining with the half-period advance at S_2 to give a change of a whole period. The length of this star will therefore also form a system of fringes, spaced at the same interval as in the first case, but with a dark fringe instead of a bright one at the central point F, and, in general, bright fringes just where the dark fringes of the first system occur, and vice versa. Since the light of both stars enters the telescope at once, the two sets of fringes will be superposed and each will fill up the gaps in the other. If the two stars are equally bright, this compensation will be complete, and the whole field of view will appear uniformly illuminated. If one is brighter than the other the fringes will not wholly disappear, but will become greatly reduced in contrast and "visibility."

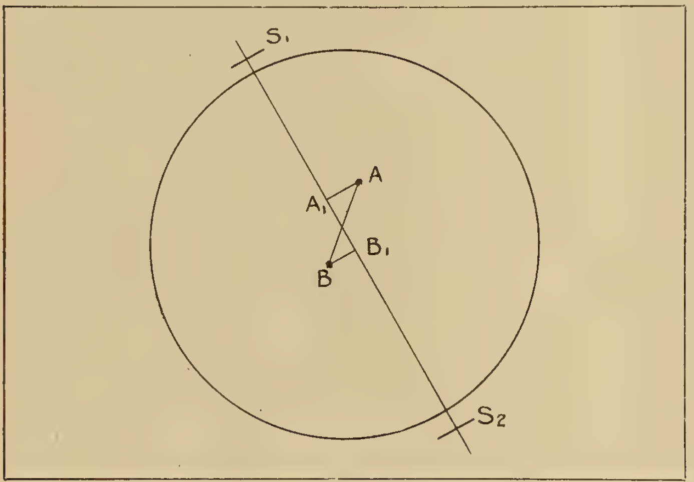


FIG. 3

If the additional distance through which the light of the second star has to travel to reach the remoter slit is more or less than half a wave-length, the two systems of fringes will be displaced relatively to one another by more or less than half an interval (as the case may be) and they will not completely compensate one another, even if the stars are equally bright. Indeed, if the path-difference for the second star amounts to a whole wave-length, its fringes will be shifted by a whole interval, and will reinforce the adjacent fringes due to the other star.

If the slits S_1 and S_2 were fixed we would therefore find it very hard to draw definite conclusions; but they are so mounted that they can simultaneously be turned toward or from the center of the mirror, and the distance between them can be changed at will. The path-difference for the second star (other things being equal) will evidently be proportional to the distance between the slits, and by altering this distance, we may readily find the position at which this difference is half a wave-length, and the fringes disappear (if the two stars are equal in brightness) or show a minimum of visibility if the stars are unequal. For a wider separation of the slits the fringes will reappear and reach a maximum of visibility, only to fade out again when the path-difference is 1½ wave-lengths, and the separation of the slits three times the initial setting (provided of course, that this greater distance is within the range of the instrument).

If α is the angular distance between the two stars, it follows by the most elementary trigonometry, applied to the triangle $S_1\ S_2\ T$ in Fig. 2 that Tan $\alpha = \frac{1}{2} \frac{\lambda}{S}$ where λ is the wave-length of the light (so that $S_1\ T = \frac{1}{2}\ \lambda$) and S is the distance $S_1\ S_2$ between the slits.

For sunlight, experiments made at Mount Wilson show that the effective average value of λ is 0.00055 millimeters, whence it follows, that the Michelson apparatus, with slits one foot apart, should detect the duplicity of a double star, by the vanishing of the fringes, if its separation was 0".19. This is just half the minimum separation of the closest pair that could be seen double with the full aperture of a 12-inch telescope. It may seem paradoxical that we can increase the resolving power of the instrument by cutting down the openings into which the star light enters, but the reasonableness of our conclusion appears when we remember that we are now taking beams of the light from the two opposite sides of the objectives which show the greatest difference of path to a point near the focal image F, and cutting out the beams which come from the central point and show a smaller path difference and less tendency to interfere.

In the actual use of the apparatus the slits are mounted on a frame which may be rotated around the optical axis of the telescope so that the line joining them may be turned into any desired direction (position angle) in the field of view. If they are so set that this line is apparently parallel to the line joining the stars, the instrument is set in position to measure the angular separation of the stars. If on the contrary, the line joining the slits is at right angles, in the field of view, to the line joining the star images the light of the two stars will reach the slits at the same instant, and the fringes produced by the two will be superposed exactly no matter how far apart the slits are set. For intermediate settings the distance corresponding to the disappearance of the fringes will be less than the true separation of the stars, being in fact, the projection of this distance upon the line joining the slits ($A'\ B'$ instead of $A\ B$) Fig. 3.

By making use of this principle, the apparent direction of the stars from one another may be determined, as well as the distance.

In applying this instrument in practice we have now a notable advantage in that we do not have to "go it blind," testing one star after another until we hit upon a double one. There are many stars which we know from spectroscopic observations to be double. From the comparative intensities of the lines in the spectra, we know the relative brightness of the components; from the spectroscopic orbits we may determine their distance apart in meters or kilometers. When we know or can estimate the parallax of the system, we can then deduce the probable angular separation of the components in the sky.

In this way it appears that most of the spectroscopic binaries, especially the white stars of short period, such as Beta Aurigae must have angular separations so small that there is no hope of resolving them, even with Professor Michelson's apparatus. But in some cases things are more favorable and we can pick out the most promising cases. Best of all is Capella. This brilliant star, one of the most conspicuous in the sky, was shown long ago by Campbell's spectroscopic observations to consist of two nearly equal components, revolving about one another in a nearby circular orbit with a period of 104 days, and a separation of at least 52 million miles (and probably more, if the orbit was not turned edgewise forward us). From the known parallax of the star, it appeared certain that the separation was at least 0".03 and direct observation with the Lick telescope showed that it must be less than 0".08; for otherwise it could have been seen double, or at least "elongated."

Dr. Anderson, working at Mount Wilson with the apparatus designed by Michelson for the purpose, found on the very first trial that with a certain setting of the slits, the fringes could be made to disappear, while, when the slits were turned with a position angle 90° away, the fringes were clear and sharp. The general appearance of the fringes in the two cases is illustrated in Fig. 4 (taken from Dr. Anderson's published article and representing photographs obtained with an artificial double star in the laboratory. The image marked "86" shows the sharp fringes visible in the second position while that marked "36" illustrates how they vanish through superposition, except near the edges of the field, where owing to secondary influences, one set predominates on the right and the other on the left. The intermediate edges show how small an angular shift of the line joining the slits suffices to alter the appearance of the fringes.

FIG. 4. APPEARANCE OF INTERFERENCE SYSTEM FROM ARTIFICIAL STARS IN THE LABORATORY

The most remarkable and encouraging fact of all remains to be told. It was found that "bad seeing" even if serious enough to interfere almost entirely with direct telescopic observation, had very little effect on the visibility of sharpness of the fringes. This was as unexpected as it was gratifying. The explanation appears probably to be that the deviations which the light waves undergo while passing through the air affect mainly the direction in which they travel rather than the time at which they reach a given point. This would account for the success of the interferometer even on poor nights, but it may be that further study will be needed before the full explanation is attained.

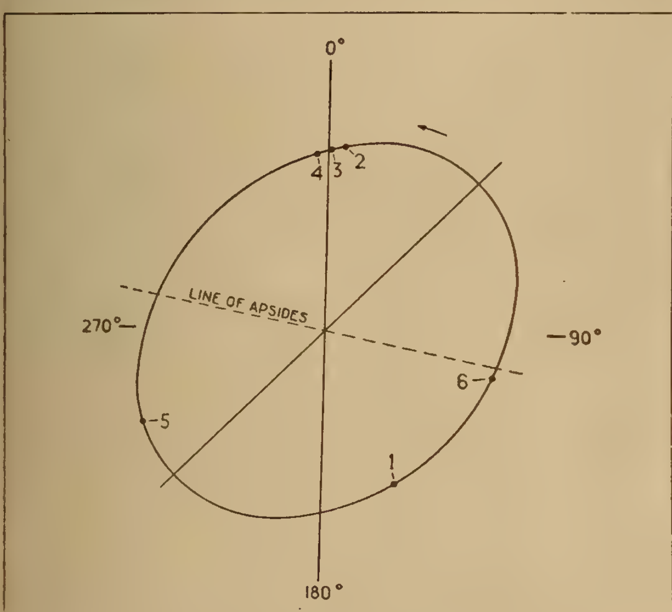


FIG. 5. APPARENT ORBIT OF CAPELLA

Later observations agreed in indicating the duplicity of Capella, and showed the extraordinarily rapid motion of the stars around one another, amounting at times to 4° per day in position angle (4° a year is pretty fast for an ordinary double star)!

Fig. 5 (also from Anderson's paper) shows the apparent orbit of one star around the other, with the six observations plotted upon it. The plotted points fall almost exactly upon the curve, indicating that the measures are very accurate. The entire interval between Observations 1 and 6 (covering more than a whole period) was less than four months (before December 30, 1919 and April 23, 1920). The maximum angular separation for Observation 5 was 0".050—one-twentieth of a second of arc, corresponding to the apparent angular size of one inch at a distance of 65 miles.

From these observations, combined with those already obtained with the spectroscope, it is computed that the main distance between the components of Capella is 81,300,000 miles; that the masses of the two stars are 4.6 and 3.6 times as great as the sun's mass, and that the parallax of the system is 0".060, corresponding to a distance of 54 light years.

Not content with this brilliant success (which indeed was regarded almost as a by-product of the main investigation, or at least as an easy test to show the practicability of the method) Michelson has proceeded to attack the far more difficult problem of measuring the angular diameters of the fixed stars.

The additional troubles here are two-fold: first the apparent diameters of the stars are very small indeed, and second, it is a much harder matter to observe the disappearance of the fringes in the case of light coming from a luminous disk than from two isolated stars with a separation equal to the diameter of the disk. In the former case the light from the middle of the disk complicates the situation and the slits have to be set more than twice as far apart to make the fringes vanish.

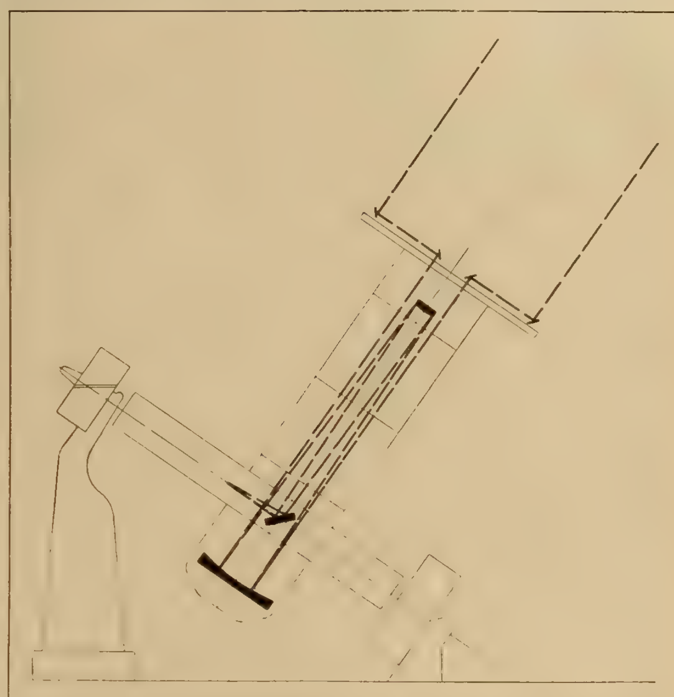


FIG. 6. INTERFEROMETER WITH SPREAD OF 20 FEET BUILT ON THE 100-INCH TELESCOPE AT MT. WILSON

To get around this second difficulty, Michelson and Hale adopted the bold course of building an interferometer with a spread of twenty feet as illustrated in Fig. 6.

A long steel beam, attached to the outer end of the 100-inch telescope carries a pair of mirrors which can be moved outward or inward and set at any desired distance. A second pair of mirrors inclined like the first at 45°, reflect the light to the great mirror of the telescope, after which it follows the ordinary path, being reflected back toward the eye-end, and finally sideways to a convenient point for observation.

So far as the optical effects are concerned the distance between the outer mirrors is the equivalent of the distance of the slits in the simpler apparatus.

The first difficulty can best be diminished by a proper choice of stars. The brightest stars, of course, are sure to have the largest apparent diameters—other things being equal—but other things are not equal in the least. White stars are

doubtless far hotter than yellow stars like the sun, and these again hotter than red stars; and the hotter a star is the brighter it shines per square mile of surface. If all the stars could be heated or cooled, keeping the size of each one unaltered till their surface temperatures were the same as that of the sun, white stars, like Sirius or Vega would lose most of their light, while red stars would be greatly increased in brightness. We cannot perform so colossal an experiment on the stars of heaven; but, from present-day knowledge of the relation between the color and the intensity of the light given out by hot bodies, we can perform it by calculation with a reasonable degree of reliability. From this standpoint it becomes evident at once that the greatest apparent diameters must belong to those stars which are at the same time *bright* and *red*. Among all the stars of the sky, these are preeminent for the combination of these characteristics: Antares in Scorpio, Aldebaran in Taurus, and Betelgeuse in Orion, or Alpha Orionis as it is often called.

Estimates made on the best available data by Eddington in England and the present writer in this country showed the apparent angular diameters of these stars were probably as great as two or three hundredths of a second of air, and hence should be within the measuring power of the new 20-foot interferometer.

The instrument, constructed last summer, was put into use at Mount Wilson this winter, and proved at once to be successful. When turned on Alpha Orionis, the fringes, which were clear when the mirrors were set six feet apart, became fainter for a separation of 8 feet and vanished when the distance of the mirrors was increased to 10 feet. White stars, like Procyon still gave conspicuous fringes at this setting, showing that there was nothing wrong with the instrument. There can be no doubt, therefore, that the diameter of the star has actually been measured. A preliminary calculation makes it 0".045—rather larger than the values theoretically predicted, but still very small, as we ordinarily reckon things. A one-inch ball, seventy miles away, would look large enough to eclipse the star completely (provided that the principles of geometrical optics could be applied to so extreme a case).

There is no doubt that the diameters of some other bright red stars can be measured, and soon will be, with the same instrument. The white stars, however, even the incomparable Sirius, are in all probability beyond its power, though still more puissant instruments capable of measuring them, may yet be constructed.

Small as the apparent size of Betelgeuse, regarded as a speck in the sky, may be, its real meaning is amazing. This star is far from being one of the near neighbors; indeed it is so far off that its distance is almost too great to measure. Observations made at Yale years ago gave a parallax of 0".030.

Unpublished photographic measures at Allegheny, and spectroscopic observations at Mount Wilson, indicate a still smaller value. He would be a bold man, at the moment, who would venture to set a value for the parallax which he would guarantee to be less than fifty per cent in error; but all the determinations agree in one respect; they indicate *that the star's parallax is less than the value now found for its diameter*, which, in other words, means that *the diameter of the star is certainly greater than the distance which separates the earth and the sun* and probably much more than a hundred million miles.

With the best data available at present, it seems probable that the parallax is about 0".015 and the diameter some 300 million miles greater than that of the earth's orbit. The added interest which this gives to the star will probably lead to additional observations for parallax, so that in a few years our knowledge will be much more precise than it is now.

Meanwhile, it is of deeper interest to realize that another milestone has been passed in the long road of our study of the universe. The stars, which from the days of the Chaldeans till now have seemed as mere points of light—specks in the sky—have at last yielded to direct observation the secret of their real magnitudes. They are no longer specks, but disks, and in a few years more we may be able to write long lists of their actual dimensions.

CLOUDS AND THEIR SIGNIFICANCE

WHEN closely observed, clouds are remarkable indices of atmospheric processes and movements. Their forms and motions may be used not only directly in determining what general winds and turbulence exist at different levels, but also in surmising the vertical distribution of temperature and humidity. Here, without the expense of apparatus, are the means for discerning what is happening in the atmosphere up to great heights, and, therefore, the means for determining the causes of certain features of our weather, and for forecasting local changes. Also, the effect of cloudiness on the temperature and humidity of the lower air is not to be overlooked.

The cloud transformations and movements during the passage of a strong low-pressure area in winter gives a fairly clear picture of the internal dynamics of such a storm. As the low approaches, a relatively warm southerly wind enters like a sideways-moving wedge over the cold surface air, and under the westerly upper wind. The lower surface of contact is frequently marked by stratus clouds formed by mixture, and the upper by alto-cumulus clouds formed by thermal convection due to the warmth of the southerly wind relative to that above. Later, the warm wind reaches the earth's surface. The lines of appreciable wind convergence are marked by nimbus and more or less continuous rainfall. Where such nimbus is formed the forced ascent of the air may go to great heights and thus supply the fast upper winds with the material for the drawn-out cirrus and cirro-stratus clouds that go far in advance of the storm and later for the heavy alto-stratus. As the center of lowest pressure goes by, perhaps not far to the north, an underrunning wedge of cold air may, by raising the warm moist southwesterly current above, bring on a few more hours of rainfall. This cold wind carries strato-cumulus clouds, formed by the turbulence and thermal convection, for perhaps a day, while the last of the long SW.-NE. lines of alto-stratus and cirro-stratus clouds, forming by the underthrust of the lower wind which lifts the higher moist layers, gradually pass over the eastern horizon.

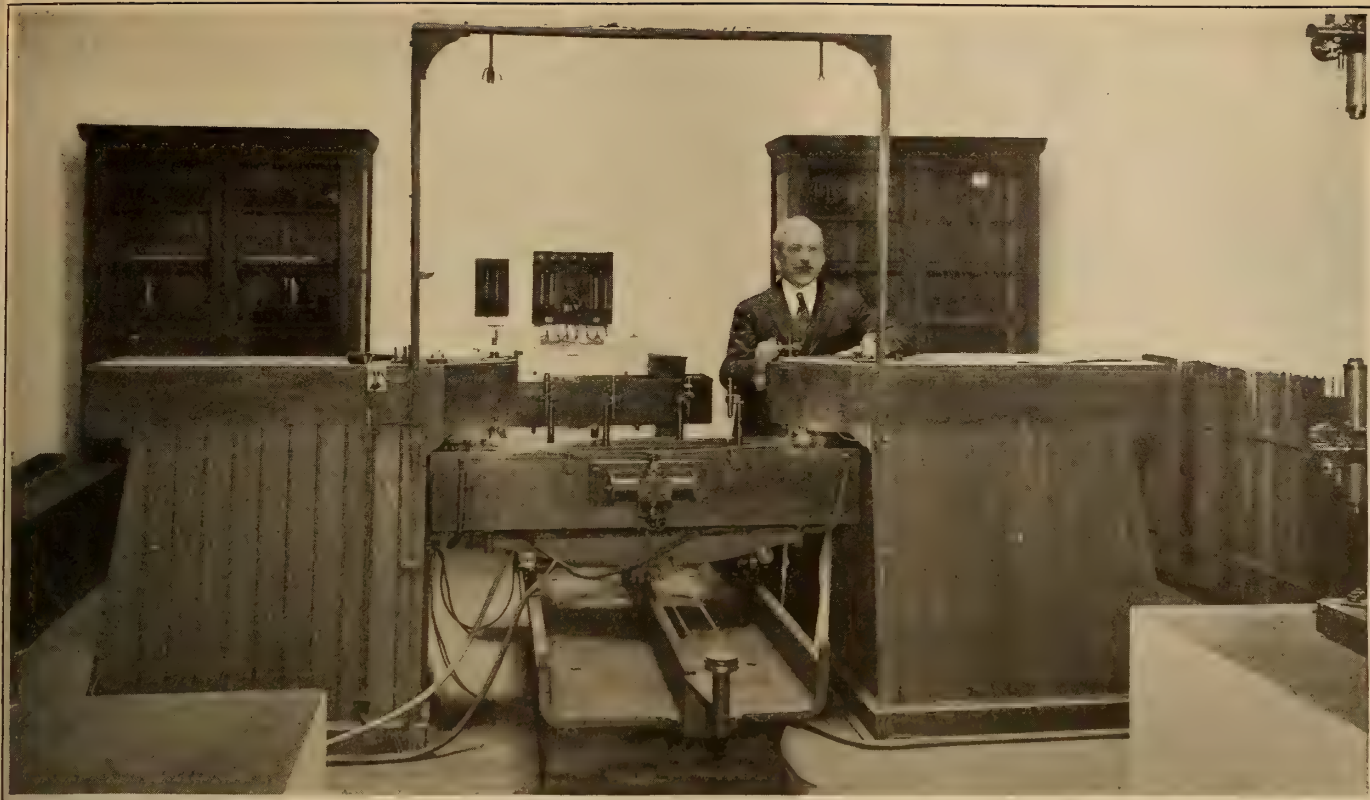
It is evident from studies of the appearance and transformations of cloud forms that the different types of clouds are very closely interrelated and pass from one form to another without any recognizable dividing line.

Since our weather is largely the result of the interaction of over- and under-running winds, clouds as indices of such are valuable in showing what is going on and what is to be expected. Cloud observations are finely complementary to pilot-balloon observations, for which there must be clear air and a lack of even intermittently intervening clouds. The whole domain of meteorology has no easier, more interesting, or more promising aspect for observations and study than clouds.—Abstract of a paper read before the Washington Academy of Sciences by Prof. C. F. Brooks.

EXTRACTION OF FIFTH ROOTS BY THE SLIDE RULE

IN view of the fact that formulæ containing 5th roots occur in hydraulic and other work, Messrs. Ginet and Gerard give a method of finding them on the ordinary slide rule.

The number, A, of which the 5th root is to be found, is read on the top scale of the rule, and the slider is adjusted by trial and error until the required root is read on the bottom scale of the rule against the I on the slide and at the same time on the upper scale of the slide against a number, B, on the upper scale of the rule, which is itself also seen on the upper scale of the slide opposite A on the upper scale of the rule. Care has to be taken that the correct halves of the upper scales are used according to the number of figures in the number before the decimal point.—Abstracted through *The Technical Review* from *Produire*, Aug. 10, 1920.



DIRECTOR GUILLAUME TESTING STANDARD METERS WITH THE BRUNNER COMPARATOR

The International Bureau of Weights and Measures

An Interview with Charles Edouard Guillaume, Winner of the Nobel Prize for Physics

By Jacques Boyer

M. CHARLES EDOUARD GUILLAUME, director of the International Bureau of Weights and Measures and 1920 winner of the Nobel Prize for Physics, was kind enough to grant an interview at his office in the aforesaid International Bureau, where he has done the greater part of his remarkable research work, and which he has been at the head of since the retirement of his predecessor, M. René Benoit, in 1915.

My kind host did the honors of this building, a veritable palace of precision, as it might be termed, which is located at St. Cloud and tenanted by a technical staff which is small in numbers, but choice in quality, as the members must needs be to handle the delicate instruments in their charge. It is impossible to try to describe in this brief article the minute precautions for the securing of accuracy, which are in force in these laboratories of the science of metrology or measurement. I will merely state in passing that all of these apparatus rest on piers of masonry having their foundations firmly rooted in the earth itself. Openings have been made in the floors of the various rooms to permit the entrance of these massive structures, so that the physicists making use of them can rely upon their solidity to prevent any outside influence from affecting their delicate balances and comparing rules.

"To begin with," said M. Guillaume, "kindly contradict the vexatiously erroneous opinion, held not only by *hoi polloi* but even by many of the learned with respect to the achievements of the metrologist. It is true enough that he is commonly conceded to have trained hands and eyes, to be a faithful observer, and to possess the inexhaustible perseverance required to make calculations involving the 10-millionth part of a millimeter, but it is too frequent a mistake to deny him the possession of creative imagination. Why, it was only the other day that some dull and tedious occupant of a professor's chair solemnly remarked that the metrologist must be compared to the plow-horse patiently digging his furrow while the man of new and original ideas is the race-horse swiftly covering space to the plaudits of an admiring crowd!

"However," continued M. Guillaume, "the metaphor is not entirely displeasing to me—for when once the race is over what is there to show for it but a little dust and a little noise, while in the furrow traced by the steady plow-horse the coming harvest will tomorrow lift its head. Is it not a patent fact, indeed, that the great discoveries of science bear a close relation to the methodical labors of the metrologist?"

And as he warmed to his theme by degrees, the eyes of the famous metrologist flashed behind his glasses, and he continued to plead with zeal for recognition of the value of the work done by the members of his craft, proving that it is their labors alone which have rendered possible the greatest advances made in physics and in astronomy since the seventeenth century.

"Did not Galileo establish the laws which govern the inclined plane by measuring the time required for a body to descend the said plane, and prove the isochronism of the oscillations of a pendulum by comparing during the course of some religious ceremony, the beats of his own pulse with the duration of the oscillation of a chandelier suspended from the vaulted roof of the Cathedral of Pisa?

"Would Newton have been able to discover the law of the universal attraction of matter but for the previous measurement of the arc of a meridian made by the French astronomer Picard at the command of Louis XIV? Was it not, thanks to the precision of their balances, that Lavoisier, Proust and Dalton were able to throw fresh light into the labyrinthine mazes of alchemy and thus transform a mass of obscure recipes and bizarre experiments into a true science—that of

chemistry? Do we not owe our knowledge of the law of the conservation of energy to the brilliant calorific measurements made by Joule and by Regnault, and that of radioactivity to no less sagacious measurements made by Becquerel and by Curie in those still more mysterious realms of research—the world of atoms and the constitution of matter?

"Furthermore, in the science of physics the constant relation between cause and effect becomes evident with certainty only from experiments in which effects are known whose various causes have been measured—more especially the weightier of these causes when the others play an obscure rôle."

THE INSTRUMENTS

But let us turn aside from these philosophic and theoretical ideas uttered by our learned guide in order to examine the remarkable instruments which, protected from the vibrations of the ground in the City of Light, enable the learned metrologists who employ them, to achieve from time to time a new decimal in their calculations of extreme precision.

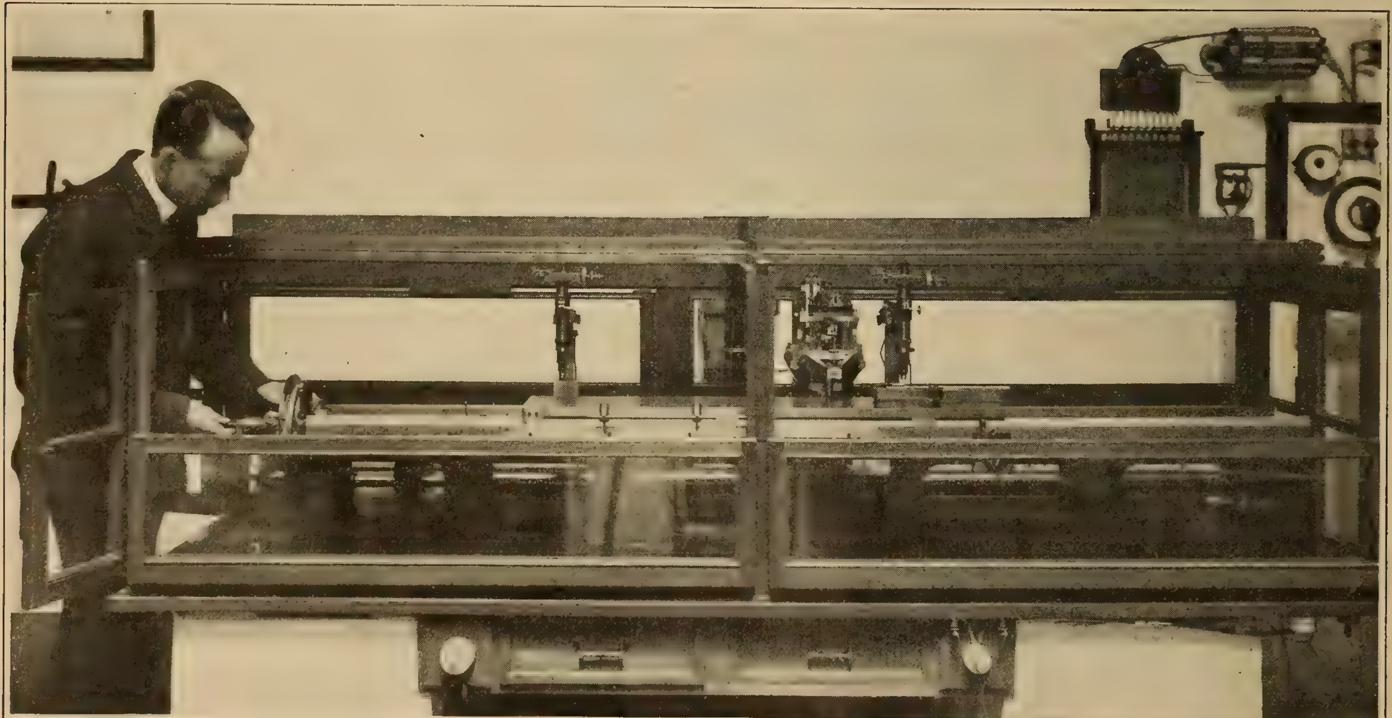
Such a conquest implies, it must be borne in mind, a very large number of improvements in matters of detail whence there will spring tomorrow some fresh discovery.

Comparators.—For the comparison of standards of linear measure, instruments known as comparators are employed. The International Bureau of Sèvres possesses several types of these. Essentially they consist of two piers bearing two microscopes a meter apart provided with micrometers, beneath which are brought, by means of special mechanisms, the two meter bars which it is desired to compare.

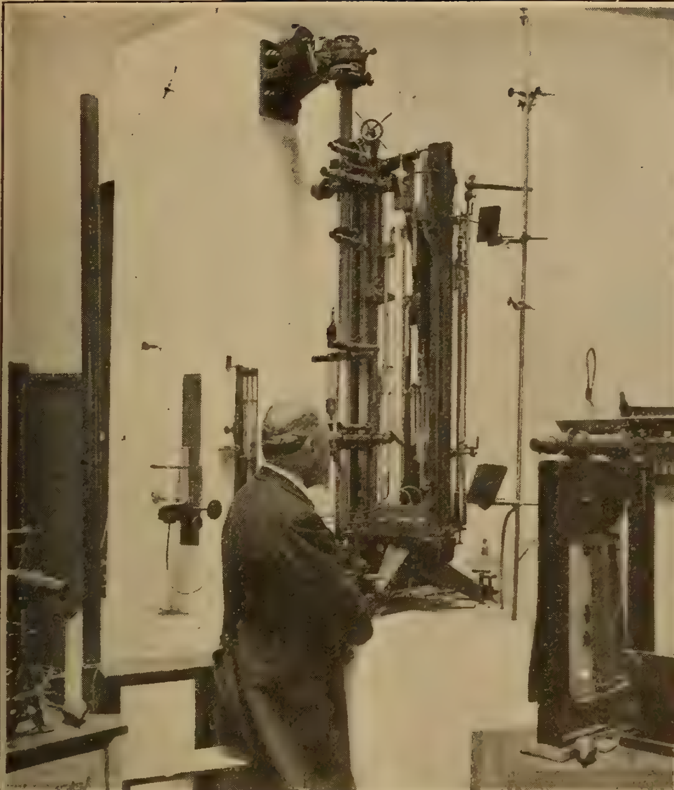
Comparators differ in details of construction according to the purpose for which they are intended. The first one built, which was the work of the Brunner Brothers, made measurements of the line type, *i.e.*, the length is measured not between the two ends of the bar but between two lines engraved in the vicinity of either end. The microscopes firmly attached to strong piers of masonry carry micrometers similar to those adapted to optical instruments. The linear divisions of the comparator correspond with the pitch of the micrometer screw thread so that the angle through which the barrel is rotated gives a measure of the displacement of the hair line of the microscope. The bed of the comparator itself consists of an enormous structure of cast iron. A very heavy carriage is rolled along a track formed by the upper edges of this bed by means of a hand crank which controls a series of gears. Two tanks are mounted on the carriage and in them the two standards that are to be compared are placed in shaved ice, or else water is circulated in a water jacket surrounding the tanks so as to maintain a uniform temperature. Means are provided for moving the bars in either a longitudinal or a transverse direction. The observer then compares the two bars by adjusting the hair line of his microscopes to the fine lines traced on one bar and, then moving it out of the way, the second bar is brought into the field and the displacement of its lines is noted.

The second comparator is employed to study the expansion of meter bars. It differs mainly from the one above in the fact that the carriage supports two tanks, one meter apart from each other; a bar is placed in each tank and they can thus be brought to different temperatures. One of them, taken as a standard of comparison, is kept at a fixed temperature, while the other one is heated or cooled. It is thus possible to measure the elongation or the contraction by comparing the length of the rule after each experiment with that of the standard. We will not dwell on the difficulty experienced in keeping the temperature constant for a sufficient length of time. Thanks to certain devices the physicists working in the Bretenil Pavilion have succeeded in keeping a liquid bath for several hours at a temperature so constant as to vary only by a few hundredths of a degree. These two instruments make it possible to determine the difference in length of two meter bars within a few microns—*i.e.*, a few thousandths of a millimeter!

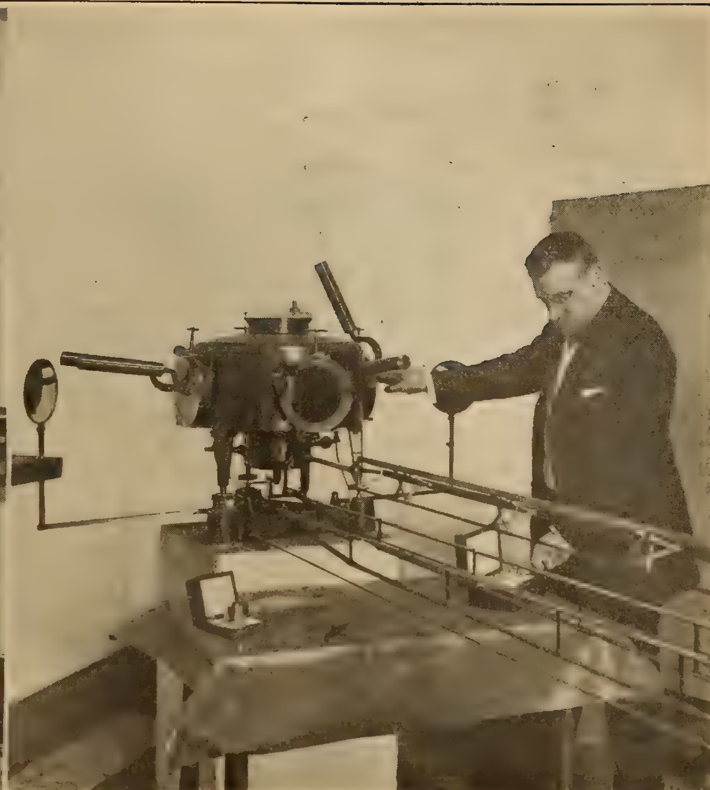
The Universal Comparator.—With this instrument, which differs considerably from those described above, the observer can make all sorts of comparisons, thanks to the fact that it has both a longitudinal and a transverse movement, and because of the mobility of its microscopes. These are no longer fixed, but are borne upon carriages rolling upon a sort of bridge placed in a horizontal position between two supports of solid masonry. A heavy iron casting terminating in steel ways upon its upper rim, furnishes an absolutely perfect horizontal surface on which the microscopes are moved. As soon as these have been brought to the required position for any given experiment, they are secured by a clamp. A heavy carriage travels beneath, and is provided with supports for the standards to be examined. Corrections can be made by various



MACHINE FOR MAKING ACCURATE GRADUATIONS ON STANDARD LINEAR MEASURES



MAKING AN OBSERVATION WITH THE STANDARD NORMAL BAROMETER AND MANOMETER



PLACING THE WEIGHTS IN THE BUNGE BALANCE WHICH MAKES WEIGHINGS IN VACUUM

complicated devices into whose details we can not here enter. Moreover, the instrument has been provided with a standard rule 2 meters long and divided into centimeters; with this also it is easy to compare end standards; to determine other lengths than those of the metric system; to establish standards of sub-multiples of the meter—especially of the millimeter—which is so necessary in order to determine the degree of precision which it is possible for the observers to attain with the micrometric instruments employed in these delicate experiments. The Hartmann comparator, for example, registers *automatically* the slightest differences of dimension which exist between the pieces placed in it. It consists of a steel bed upon which are two bases, one of which is fixed, while the other is capable of sliding along the bed. The first carries a micrometer screw whose head is surmounted by ten arms, each of which carries a pen similar to those found in registering-barometers. The point marked by the pen upon the recording drum, toward which it is attracted by an electro-magnet, indicates the length of the standard. With this instrument the difference in length between two pieces can be determined quickly and with considerable precision.

Finally, in order to verify the geodetic rules, which are four meters in length, a special instrument is employed which is formed by the association with each other of five comparators. In order to eliminate the slightest variations of temperature which might falsify the results obtained in the observation, the rules to be examined are placed in a closed container, filled by a continuous current of water kept at a fixed temperature. The manipulation of this geodetic comparator is done by electricity and is very complicated.

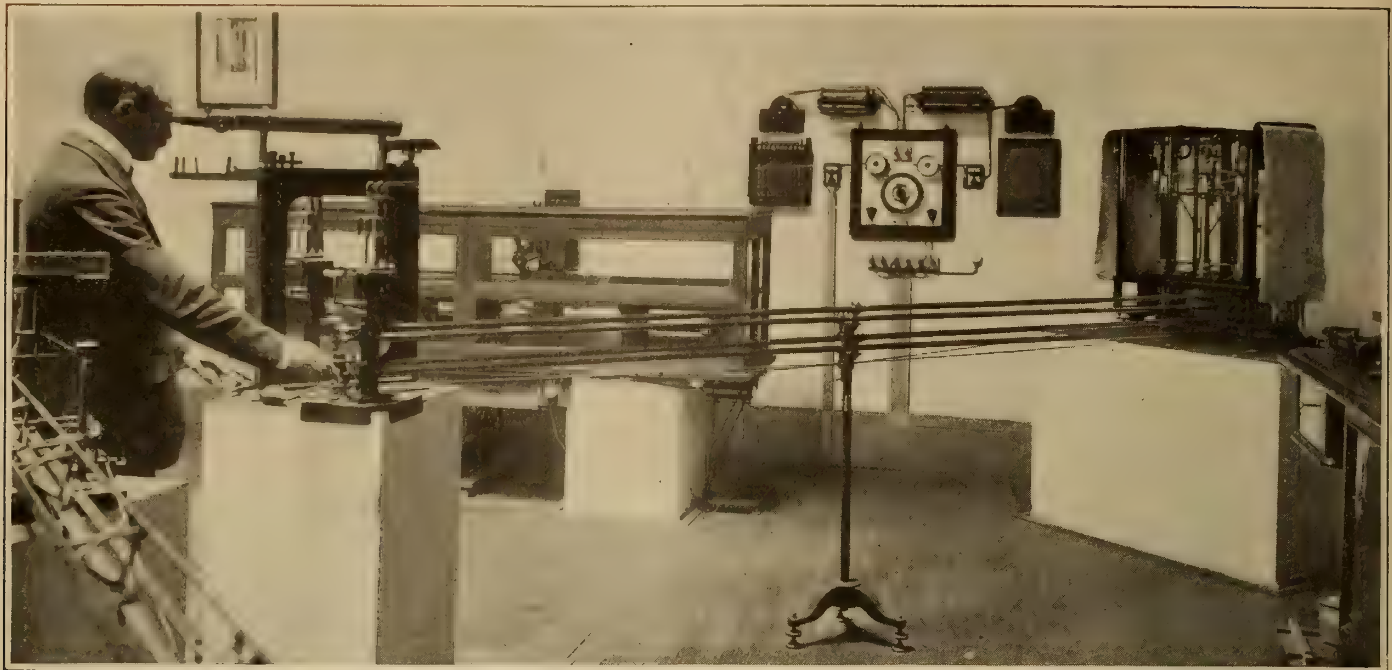
Precision Balances.—Let us pass on now to the second class of instruments found at the International Bureau of Weights and Measures. These are precision balances of great delicacy, nearly all of which are so constructed that they may be read at a distance. Insulated in glass cages supported on piers of masonry which do not touch the floor, they are employed to make comparisons of mass, especially of standard kilograms. One of them, made by Dr. Bunge, is even capable of determining weights in a vacuum. Let us enter the room which contains them in the company of Prof. Guillaume's assistant, M. Vollet, who has charge of this department, and listen to his explanation of the manner in which an experiment is performed.

The day before that fixed on for the experiment the observer places in the cage of the apparatus the weights needed for the next day's work; he then avoids approaching the balance lest thermic disturbances be produced by the heat from his body. Twenty-four hours later, by means of one of the long metal rods which are seen in one of our illustrations and which rest upon solid blocks of masonry, he performs the desired weighing operation at a distance of 4 meters. In other words, the ingenious mechanism at his disposal enables him to place the weights upon the pans, to release the latter, etc., without coming near the scales. He watches the oscillations of the beam of the balance by means of a small telescope. A mirror firmly attached to the balance beam reflects a graduated scale whose movements made when the beam oscillates are seen by the experimenter through the telescope. It is only ncessary for him to note its extreme successive positions, then find the average, and the position of equilibrium can be deduced therefrom by means of a simple calculation.

We shall not dwell here upon the various devices invented by Rueprecht, Bunge and other makers of scientific instruments by means of which the physicists on the staff of the International Bureau can determine the difference between two kilogram weights to within about 1/100 of a milligram, while in other rooms temperatures are measured with a precision hitherto unknown.

Modern Geodesy.—"But now," said Prof. Guillaume, "we must go down into the cellar in order to comprehend the work done in connection with modern geodesy. As you doubtless know, it was I who, together with my predecessor, M. Benoit, suggested the use of wires made of *invar* to measure secondary bases."

But the modesty of my guide kept him from adding that it was he himself who had discovered the anomaly in the case of the nickel steels, those famous alloys known under the name of *invar* (an abbreviation for invariable). Let us briefly



COMPARING STANDARD KILOGRAMS FROM A DISTANCE SO THAT THE HEAT OF THE BODY WILL NOT AFFECT THE DELICATE INSTRUMENT

remind those of our readers who are rusty in their metallography that alloys having 25 per cent of nickel expand much more than would be indicated by the law of mixtures of metals, but that when the nickel is added by degrees the expansibility is observed to become rapidly lower, passing through a minimum, at about 36 per cent of the nickel, and then ascending until it reaches the degree of expansibility of nickel. Those alloys which approximate the minimum bear the generic name of invàr, and their expansibility when they have been merely laminated while hot and then air cooled is only about one-tenth that of their constituents. Furthermore, Guillaume has shown that it is possible, by means of certain thermic and mechanical treatments, to reduce even this low degree of expansibility and to obtain *anti-expansible alloys*—*i.e.*, alloys which actually contract when heated. New thermic treatments offset the expansibility of these alloys, so that they can be brought if so desired to a state in which the expansion is *nil!*

By means of the theoretic data thus obtained the steel works of Imphy, of the Society of Commentry-Fourchambault, and the Decazeville have thus been able to obtain for geodetic measurements many kilometers of wire practically without capacity for expansion. The use of these wires in connection with the rapid method invented by the Swedish geodetic expert, Jaderin, has made it possible entirely to transform the measurement of bases by combining a light and easily handled material with wires of invar freely stretched between two definite bench marks. In this manner it has been possible to reduce the cost of measuring bases to 2 per cent of its former cost without sacrificing precision. The measurement of the Simplon is a classic example of this new mode of measurement. In order to subject these invar wires to a permanent control, M. Guillaume has constructed in the cellars of the International Bureau a reference base 24 m. long, consisting of a series of bench marks sealed into a thick wall. At the two extremities of the base are two pulleys mounted in ball bearings over which pass flexible cords attached to the wire and stretched by weights weighing 10 kg. each. Two observers are placed opposite these bench marks, which are strongly illuminated by the light from powerful projectors, and bringing toward each other the graduated rules in which the wires terminate, they make a series of simultaneous readings of their respective bench marks with respect to the graduation of the rules. In this manner the wire is compared at the base.

For the movable bench marks, whose distance apart upon the ground is determined, two by two, M. Benoit and M. Guillaume have invented a huge wooden tripod on top of which is a movable table. Upon this table is placed a small metal tripod kept in position by 3 springs, upon which rests a plate surmounted by a vertical pin whose micrometric movement is secured by the aid of 3 horizontal screws. The pin is pierced by a vertical hole through which passes a plumb line.

A base can be measured much more rapidly by means of this system than by the old methods and requires a smaller staff—only about 10 men. Finally the possible error does not exceed a millimeter.

Another of the most remarkable pieces of research to be found at the Bureau is the work which the learned American scientist, Michelson, has been pursuing here for the last 20 years. This skilled man of science has succeeded by processes into whose details it is impossible here to go, in comparing the fundamental base of the metric system with a natural unit, the length of the wave of the red light of cadmium. This unit is dependent only upon the properties of atoms and of the ether. It appears, therefore, in the words of its author, "one of the most fixed magnitudes throughout the whole realm of nature." His delicate experiments have given the following figures as the average value: 1 meter = 1,553,164 wave lengths of this radiation in the air at 150° C. and at a pressure of 76 cm. Thus it is possible today to declare that if all our standards should disappear in some vast cateclysm, it would nevertheless be possible to restore them by reversing Michelson's process since with the data of his treatise upon the subject all the units of the metric system could be found. The French astronomers of the 18th century were not in error as to the future of the meter when they gave it the proud device—*For all times and for all peoples.*

The present director of the International Bureau of Weights and Measures continues, therefore, the proud tradition of his famous forerunners and he has personally done much to spread the use of the metric system throughout the world, although our English and American allies still refuse to adopt it officially as a whole.

When my visit to the laboratories of the Breteuil Pavilion had been concluded, M. Guillaume led me once more into his office, whose windows give upon the valley of the Seine.

Here he entertained me by way of finale, with an account of his latest researches—in particular with the applications of nickel steel to the science of chronometry.

The combination of the brass in a balance wheel with an alloy containing 42 per cent of nickel has enabled us boldly to attack the problem of the secondary error of chronometers which had long exercised the ingenuity of horologists, but had been only partially solved at the expense of much complication of mechanism. Thanks to the use of the Guillaume balance, considerable advance has been made in the construction of chronometers of precision—and this progress is shown by the annual reports of the observatories, in particular those from Besançon.

The Spiral Compensator.—The *elasticity* of nickel steels furnishes as great an anomaly as does their expansibility. This was discovered in invar by Marc Thury and by Paul Perret simultaneously; it was first studied by the latter physicist in collaboration with M. Guillaume and led to the construction of the spiral compensator by whose use we are able to dispense with the use of the compensated balance, in ordinary watches at any rate.

M. Guillaume had always believed that this spiral might become an element in a provisory solution of the problem. However, up to the present time more than 50 million watches have been provided with spiral compensators, and this has enabled manufacturers to lower greatly the price of common watches.

As a result of his study of the ternary alloys, *i.e.*, those which contain a third element besides iron and nickel—particularly chromium or magnesium, M. Guillaume came to the conclusion that it would be possible to obtain an alloy having a constant elasticity and thus obtain a more perfect solution of the problem. It was only in last July (1920) that he announced the completing of the invention to the Academy of Sciences. This announcement occasioned a tremendous sensation among horologists, since it was instantly preceived that it implied a highly important change in the system of compensation in chronometers.

TESTING A WIRE FOR SURVEY WORK

The New Alloy Elinvar.—This remarkable alloy has been termed by its inventor *elinvar*, an abbreviation of the words *elasticity invariable.*

I must not forget to add this article M. Guillaume's closing words to the effect that he had come to France 37 years ago expecting merely to work here for a few months and then return to his Fleurier, in Switzerland, his native land. "But the elegance, the lucidity, and the precision of French methods of research have seduced me to stay and have led me to achieve success," were his closing words.

PURIFYING STEEL INGOTS WITH ALLOYS OF TITANIUM

The employment of titanium as an alloy for steel makes it possible to obtain steels having a very homogeneous composition without flaws, cracks, or inclusions of gas or foreign bodies—furthermore, it diminishes the effects of segregation. In the Revue Universelle des Mines (Liége) for April 15th, M. Bertrand furnishes the following interesting information concerning this rare metal:

The best known mineral containing titanium is rutile or titanium oxide, TiO_2 which is found in igneous and metamorphic rocks. This mineral contains from 98 to 99 per cent of TiO_2, the remainder consisting of oxide of iron. There are several crystalographic varieties: Brookite, anatase, and octahedrite. The principal deposit is found in Norway, but it also occurs in Virginia, in Dahomey, on the Gold Coast, on the banks of the Niger.

The most widespread mineral of titanium is ilmenite $FeTiO_3$ which contains a maximum of 52 per cent of titanic acid. Abundant deposits of this mineral are found near the coast in Canada, in the Senegal, and in New Zealand; these proceed from the disintegration of shallow marine deposits.

Thus far no use has been found for the pure metal; it is employed only in the form of alloys which are both more fusible and more readily obtained, principally in the state of ferro-titanium, and ferro-carbo-titanium, but sometimes as cupro-titanium and as mangano-titanium.

Ferro-titanium is produced by the German process, known as the Goldschmidt process (alluminothermy), by which the reduction of the mineral is secured by means of powdered aluminum; this has the serious disadvantage of being very costly because of the large quantity of aluminum required. Ferro-carbo-titanium is prepared by the Rossi process in the electric furnace in which a mixture of the mineral with charcoal is reduced. The following table gives comparative analyses of these two alloys:

Elements	Ferro-titanium	Ferro-carbo-titanium
Ti	25.00	15.79
Fe (per difference)	68.19	74.30
C	0.00	7.46
Si	1.25	1.41
Al	5.50	0.80
Mn	0.00	0.11
S	0.01	0.08
P	0.05	0.05
	100.00	100.00

Steels are more and more employed at the practical maximum of their resistance, which necessitates as high a degree of purity as possible. For this reason great effort has been made during recent years to avoid flaws and cracks, to remove foreign bodies and gases and to annul. so far as possible, the effects of segregation. This has been accomplished in part by projecting aluminum into the pocket of the mold at the moment when it receives the molten metal. However, it is necessary, in this case, to sacrifice the upper portion of each ingot where the metal presents a network of flaws and of slag, and where the cooling produces a more or less deep retraction pocket. A more serious matter consists of the fact that the aluminum produced from alumina does not fuse until it reaches a temperature of 2,050° C., whereas the fused metal has a temperature of about 1,600° C.; hence the alumina remains in a solid state in the bath and forms a lump in the steel.

PHOTOGRAPH OF THE NEW CONE OF MOUNT VESUVIUS TAKEN FROM THE FLOOR OF THE OLD CRATER. THE CONE IS IMMEDIATELY ABOVE THE OLD VOLCANIC CONDUIT

LAVA OVERFLOWING FROM THE NEW CONE AND MELTING ITS WAY INTO HARD LAVA PREVIOUSLY SOLIDIFIED

Volcanic Architecture

How Vesuvius Rebuilds Its Broken Cone

By Frank A. Perret, Volcanologist

Illustrated with Photographs by the Author

READERS of the SCIENTIFIC AMERICAN MONTHLY will no doubt recall the great eruption of Vesuvius in the spring of 1906. Before that event, the cone of the volcano had been built up to an elevation never before attained, with a pointed summit and a small crater. The eruption cored out, undermined and blew away the entire top of the mountain, leaving a great crater half a mile across and a thousand feet in depth, and producing a profound change of form.

Then followed seven years of external repose during which time not so much as a thread of smoke could make its way through the plug of débris which clogged the conduit of the great volcano. But the lava was silently eating its way upward, and early in July, 1913, a vent was formed at the bottom of the abyss, with the familiar glow of former times. From this opening there gradually welled up the new supply of lava which has been filling the great cavity and building up the base of what will constitute the new and greater cone. The embryo of this cone (formed of the lava welling up and thrown out from the vent) already exists, and may be seen in one of the accompanying photographs rising above the level of the crater floor.

The author of this article, Frank A Perret, volcanologist of the Smithsonian Institution, is well known as a most daring investigator in this extremely hazardous field of scientific research. He became honorary assistant to Professor Matteucci of the Royal Observatory at Mt. Vesuvius in 1904 and made a special study of the great eruption of 1906. He also studied the eruptions of Stromboli in 1907, 12 and 15, and Messina in 1908. For his valuable services which resulted in the saving of thousands of lives he was knighted by the King of Italy. Having witnessed the demolition of the great cone of Vesuvius fourteen years ago, he is naturally much interested in watching the gradual construction of a new cone in the floor of the old crater.—EDITOR.

Now, when I speak of the crater floor, people protest. They object to the crater having a floor. They think of it as an opening leading down to the realms of Pluto, so how can it have a bottom? And yet the matter is very simple. "Crater" means cup, and it is generally more like a basin; and a basin has a bottom, even though there may be an opening in it—the point is that the opening is smaller than the bottom of the basin, and not only so, but the opening—when the volcano is active—is full of a heavy liquid rock, so there is no real cavity. Furthermore, as the liquid is generally rising, it accumulates around the vent and builds up a

mound—a cone—to a considerable height above the crater floor. And so the floor level is always rising, not by being pushed up from below, but by the superposing of material which overflows from the pipe, so that when we spend a night on the crater bottom, our camp of the year before lies buried some hundred feet below, and the changed conditions require also a horizontally different site, in order to find a happy medium between the extremes of heat and cold.

Here, again, people protest. They object to my feeling cold at the bottom of a fiery crater, where one can read all night by the bright glare of incandescent lava. They cannot possibly object to it more than I do, but the fact remains that it is cold at night, even in August, and the explanation is, here also, a very simple one. For, although the crater may be—and was—a thousand feet deep, it is at the top of a mountain four thousand feet high, so that a person at the bottom of the crater—instead of being nearer to the center of the earth than the average mortal—is three thousand feet above sea level, and at that height the air is cold at night, even though there may be red hot lava fifty feet away. The difficulty is, as I have said above, to find a happy medium.

If the present average rate of activity continues, we shall see from Naples, in a very few years, the little cone peeping above the rim of the great crater, and from that moment Vesuvius will begin its transformation of shape until once more the great cone of the mountain will be regular, terminating in the pointed summit made familiar by postcards without number. But from the present time—and for ten years to come—this volcano will constitute one of the most imposing spectacles on earth—a great crater, upon the edge of which one stands in perfect safety, and looks across at an actively erupting cone whose ejections are filling the basin and building the new mountain from which—still later—will burst forth another great eruption to complete the cycle.

DESCENDING THE OLD CRATER WALL

The wall is 350 feet deep having been filled in with lava from a depth of 1,000 feet since the great eruption of 1906.

THE CELESTIAL SPEED RECORD

Spectroscopic observations of the nebula Dreyer No. 584, in the constellation of Cetus, show that it is receding from us at the frightful velocity of nearly 2,000 kilometers (1,240 miles) per second. The observations were made by Dr. V. M. Slipher of the Lowell Observatory. This beats the previous celestial speed record by about 800 kilometers. Most objects move through the heavens at less than 100 kilometers per second. The earth jogs around the sun at the leisurely pace of 30 kilometers per second, 30 times the speed of a bullet.

MEASURING THE TEMPERATURE OF THE LAVA FLOWING FROM THE NEW CONE, WITH AN ELECTRICAL PYROMETER

The temperature registers 1,850 degrees Fahrenheit and the assistant is obliged to avert his face from the blistering radiant heat

The Place of Life in Nature*

How Is It Related to the Cosmos, the Greater Part of Which Is Non-Living?

By Ralph S. Lillie

IT is a peculiarity of our status as self-conscious beings, whose existence and activities are bound up with the special form of material organization called vital, that life appears to us as the central and all-important fact of nature. The qualities of living beings are always present to our attention. In most of us the feelings of activity, energy and spontaneity are strongest when organic life is strongest—when we are most "alive"; the popular meaning of the word *vitality* comes from this fact; and the naïve tendency has always been to ascribe a special freedom or originative capacity to life, and to regard the non-living part of nature as something radically different from the living, as something inferior—or basely mechanical. But obviously this view, as the product of prepossession rather than reasoning, can have no scientific or evidential value in relation to the problem of the place of life in nature. Most of us can remember wondering as children at the absurd self-importance of inferior animals like house-flies; later on we find that this curious self-regarding attitude of living beings is simply one of their general or "class" characteristics, shown even by plants. It would appear therefore that when man—who is certainly not the least egotistic of the animals—assigns to life a position of central importance in the cosmos, he may be merely furnishing another example of this natural propensity, which has its biological origin in the inherently self-conserving or self-protecting tendency common to all organisms. This property is a necessary condition of organic survival; it is an example of what is called an "organic regulation" and even has its analogies in various automatically regulated mechanical devices. We must face the possibility that in reality life has no unique or privileged position in nature, but is merely one out of the many purely casual and inessential results of the operation of blind natural forces. At least a biocentric conception of the cosmos must justify itself on other grounds than those of the instinctive human prejudice.

I propose this evening to discuss the question of how life is related to the rest of nature, the greater part of which is non-living in the usual understanding of the term. How is this peculiar and special development which we describe as *living* to be derived from a cosmos which close observation shows to be subject everywhere to rigid determination by mechanical and mathematical laws?

What, then, is the essential relation of life to the cosmos? In earlier times mankind regarded the world and its inhabitants as something emanating from life, as created and sustained by the volition of a living deity or deities, and as subject to more or less arbitrary divine—or sometimes diabolical—intervention; life was the primal cause or originating condition of things; the deity breathed into his creations the breath of life; by this action something not previously present was added to nature; in a word, the source of life was "supernatural." How far we have traveled from this naïve belief in these scientific days I need scarcely remind you. To most of us, especially biologists, life is not a primitive but a comparatively recent and derived phenomenon, one product of the evolution of a cosmos which at first was entirely non-living; in the temporal or historical progress of nature complex or "heterogeneous" systems, including finally life, by degrees emerged from the originally indefinite or homogeneous primordium (to paraphrase Spencer); life as thus conceived is not a primary agency, but a secondary and somewhat exceptional derivative of the natural process. This view seems now firmly based on naturalistic observation; and in fact it is usually regarded as a summarized objective description of what has happened during the past several million centuries.

The question of whether or not to accord primacy to life is perhaps not one to be settled by observation alone. When we view cosmic events in their historical succession it seems certain that life is a later rather than an earlier appearance in nature; there is no doubt that the physical conditions on the globe were incompatible with the existence of living matter until a comparatively late stage of planetary evolution. But the argument from the geological succession of life on the earth is an equivocal one and not decisive, since its opponents may well reply that the very appearance of life at a certain stage implied its previous latency; how otherwise in a mechanistically controlled world could it ever have come into existence? The character of the dilemma is evident; in any physico-chemical view of natural evolution the casual chains extend back indefinitely and uninterruptedly; whatever appeared at any time or place in the sequence was in this sense predetermined—had a series of mechanistically interconnected events leading up to it. The reference to preëxisting causes thus stretches back *ad infinitum*, and whatever existed at any time, however remote, must be referred for its ultimate causal determination to what we can only call, however vaguely, the original constitution of nature. Yet it would seem that we cannot assign a physical but only a metaphysical meaning to this phrase. Claude Bernard recognizes this dilemma and comments upon it, but without concerning himself greatly, since he was satisfied that for the solution of concrete scientific problems (in which he was mainly interested) only physico-chemical or experimental methods have any real value. Apparently it is now agreed among philosophers that casuality, while a constant feature of natural existence, as it presents itself to our senses, is not a factor to be appealed to in accounting for ultimate origins.

Defining the situation in this manner enables us to formulate the alternatives of the problem somewhat more clearly. We may put the matter thus: Is life a development from physical nature, peculiar only in expressing or exemplifying in an intensified or centralized form certain fundamental features or tendencies of natural processes? Or is it a special agency or activity set apart from non-living nature, having peculiarities which are sharply contrasted to the inorganic and not derivable from it? These would seem to correspond to the alternatives of a natural *or* a supernatural mode of origin. If life is a product of natural evolution, is it an expression of a deeply rooted or essential property or characteristic of nature? or is it a casual product, one of the many purely mechanical effects of what used to be described—in a phrase vaguely irritating to many persons—as a fortuitous concourse of atoms? It is to be noted that the former alternative recognizes a certain preëxisting trend or directive tendency reaching eventually its expression in living organisms; and it therefore seems more consonant with a vitalistic interpretation; the underlying "urge" or originative impulse which is postulated might be designated by Bergson's term, *élan vital*. The other is the mechanistic alternative, which regards the peculiarities that seem to set life apart from other natural processes as simply the result of the physical and chemical properties of the special material complex called *protoplasm*, especially its properties of constructive metabolism and growth, which are dependent on certain special and primarily accidental features of its physico-chemical constitution.

Let us now consider life as a fact of external nature and inquire what are the objective criteria of living as distinguished from non-living matter. First we observe that living

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matter is not found diffusely distributed, but always as forming a part of some special organism. Many individuals of each species, similar in their activities and structure, are found, each in its appropriate habitat. The existing species of animals and plants are as a rule true to type and readily distinguishable from other species; individuals of the same species are closely alike, although somewhat variable. Thus the repetitive tendency, universal in non-living nature, exhibits itself also in living organisms; but living species are on the whole more clearly defined and exhibit fewer intergradations than non-living species, *e. g.*, of minerals; a highly specialized and individualized character seems to belong to the forms of living matter. But all of these forms have in common certain highly definite class properties, not ordinarily met with in non-living matter; and it is first necessary to state these as clearly as possible.

Living matter is sharply distinguished from dead matter by various remarkable peculiarities of activity or behavior, and by a unique physico-chemical and structural composition. The most striking feature of its activity is its power of growth or self-multiplication; this is shown by all of its forms, from the lowest plants to the highest animals. With the property of growth is to be included that of reproduction, which has been defined as discontinuous growth; *e. g.*, a cutting from a plant will grow into the complete organism under appropriate conditions; so also will a seed, which is equally to be regarded as a detached portion of the parent organism; and similar conditions are found in animals (regeneration, sexual and asexual reproduction), although here the extraordinary complexity of the process by which a fertilized egg develops into the adult seems to give the reproductive process a special status of its own. Even in this case, however, the essential nature of reproduction as orderly and specific growth toward a definite final organization is clear enough. All living material, then, is *growing* material—at least in certain stages of its existence, for there are natural limits to the increase in size of the individual in higher plants and animals—in other words, it is *synthesizing* material; and this brings us to what is apparently the essential feature of living organisms, considered as physico-chemical systems. All living matter is more or less continually engaged in transforming unorganized materials and energy taken from the surroundings into organized living material of its own kind. It thus tends automatically to add to itself; what is appropriated from the surrounding non-living world is actively transformed into its own organized and active living substance. This transformation is *specific; i.e.*, a special type of living matter or protoplasm, with a chemical composition, structure and activity identical with those of the original protoplasm, is formed. Each portion of protoplasm thus serves as a center of construction of similar forms. This condition has certain analogies to "germ-action" in inorganic processes, such as crystallization, but on the whole is a unique and distinctive property of living organisms. This property depends on certain highly definite processes of chemical transformation which have their special or individual characteristics for each species of protoplasm. If we put two different species of yeast or bacteria into the same culture-medium, each builds up protoplasm of its own kind; *i.e.*, each effects a special predetermined kind of chemical transformation in the materials which it incorporates from the surroundings. Each has the same external materials as its source of supply, but each transforms them in its own specific way, and hence builds up a special kind of protoplasmic structure which, having a special physico-chemical constitution or organization, exhibits corresponding special activities. The term *specificity* denotes this peculiarity. We thus conceive of each cell or each portion of protoplasm as primarily a center of specific chemical transformation or synthesis. Its other specific properties follow from this, including its power of maintaining these characteristics intact and transmitting them to other portions of living matter arising from it in growth or reproduction. "Heredity" is the name usually applied to this latter process; but it is important to note that the power of reproducing or replacing itself is one which is at all times active in living protoplasm. The living substance is continually being chemically decomposed or broken down by its own energy-yielding processes (usually oxidations of some kind), and unless there is a compensatory process of construction or replacement it sooner or later ceases to exist as living. The processes of specific construction must therefore balance or exceed this destruction if life is to continue; excess of construction implies growth, or increase in the quantity of living organized protoplasm; and reproduction is an aspect of growth, as already pointed out. In this sense "heredity" is always being manifested in living organisms; as Haldane puts it, "heredity is for biology an axiom and not a problem," *i.e.*, when dealing with living matter biologists assume or take for granted its specific transformative and synthetic power, just as chemists take for granted chemical affinity. The physiological units of the speculative biologists (gemmules, pangens, ids) have always been endowed by their creators with the property of automatic self-perpetuation and reproduction; and just at present this property is assumed without further question to be possessed by the chromosomes, which most geneticists regard as the bearers of hereditary qualities in higher organisms. But in the physiological sense no such theories of heredity can be regarded as ultimate; if chromosomes (*e.g.*,) determine the appearance of certain special characters in organisms (as now appears almost certainly to be the case), what determines the appearance of the special qualities possessed by a given set of chromosomes themselves? Surely not a second set of chromosomes—*i.e.*, similar physiological units of a lower order? Evidently these would require a third set of determinants, and so on *ad infinitum*, like the fleas in Swift's epigram. But the facts of physical science forbid any such *regressus*, since limits to divisibility are set by the atomic or electronic constitution of matter. The self-multiplying property of living matter is in reality an expression or consequence of the specific constructive side of its metabolic processes, and the problem of heredity resolves itself ultimately into the problem of the physico-chemical conditions determining this peculiar synthetic power.

Specific chemical transformation is the form of physical activity which is essential to living matter. There is an interesting general significance in this fact, for the most striking feature of chemical reactions, as distinguished from other natural processes, is that through their means substances are formed having properties entirely different from those of the original interacting substances. There is always the generation of novelty, the appearance of qualities and modes of behavior not deducible (at least at present) from those of the parent bodies; and it is this peculiarity which has enabled the life-process to create out of carbon compounds, salts, and water such a multitude of novel and varied forms. The synthesis of special chemical compounds in metabolism, in special structural and other relationships, thus makes possible the appearance of the qualities which we call vital. All living beings are primarily products of metabolism, in this general sense; they are formed, maintained, and perpetuated by processes of chemical transformation. They represent, in the purely physico-chemical sense, special collocations of matter and energy; and yet their synthesis in the manner broadly indicated necessarily involves the synthesis or creation of many other properties and modes of action which are of a different and higher order and give rise to the special conception of *vital*. The chemical process is the foundational one, but it brings into being systems having qualities whose existence could never have been predicted from a consideration of the chemical processes alone. These "vital" qualities have properties of their own requiring special modes of consideration and investigation. The organism is undeniably a physico-chemical system, but it is something else in addition. We come now to a consideration of the more specifically vital properties.

How can such complex systems as living organisms maintain themselves or even continue to increase and multiply in a nature which seems on the whole unfavorable to the preservation of special configurations of a complex type? Part of the answer has already been indicated. An organism maintains itself because its dissolution is normally balanced by an accompanying reconstruction; its materials and energy are replaced as rapidly as they are lost or destroyed, and hence the dependent vital characters, however complex they may be, are enabled to persist. In this general respect living organisms resemble certain other natural systems whose permanence also depends on the maintenance of a balance between integrative and dissipative processes of various kinds; a candle flame, a whirlpool, and fireworks such as the "devil's fountain" are instances; their persistence and individuality are due to an automatically controlled balance of diverse activities. The general class of physical conditions called *equilibria* enters here. Experience shows that two equal and oppositely directed forces or tensions produce where they come into contact a stationary condition, permanent unless disturbed; static equilibria, as in a balance or a stretched spring, are of this kind. Hence such equilibria can be represented by mathematical equations—a certain quality being recognized in the conditions determining the permanent state in question. The class of equilibria represented by organisms is of a more complex kind; they represent equilibria of processes, often called "dynamic equilibria." Any number of separate processes or activities, whose effects, taken singly, are of the most varied and frequently opposed kind, may be so coördinated that the total or resultant system preserves a constant recognizable character or unity. The component activities may be collected into two groups, which may also conceivably be symbolized by the expressions on opposite sides of an equation, the constructive or integrative processes of the one side balancing the destructive on the other. Each group, taken collectively or additively is equal and opposite to the other in its total or resultant effects; hence the two compensate each other and produce a stationary total condition. Thus when constructive and destructive metabolism in a living organism are equal there is balanced maintenance, indicated, *e. g.*, by nitrogenous equilibrium; when the one or the other exceeds there is either growth or regression. In all organisms the conditions making for dissolution are various. Take the case of a simple marine plant or unicellular animal as an illustration: the mechanical and chemical action of the environment, the tendency of protoplasmic materials to diffuse into the surrounding sea-water, and especially the continued oxidation of protoplasmic constituents and loss of carbon as CO_2, all combine to diminish the living substance; this loss is replaced during life by the intake and transformation of food materials. When, however, the synthetic processes cease, as at death, the destructive processes are unbalanced and the organism is quickly disintegrated. On the other hand, with an abundant food supply and otherwise favorable conditions the synthetic process may predominate and lead to indefinite growth and reproduction.

Now this conception is applicable to all forms of life and also to life in its totality; its persistence implies that disintegrations are balanced or overbalanced by integrations. In the extraordinary diversity of organisms we find an infinity of different means by which this vital balance is maintained. When it is not maintained, as repeatedly happens in nature, a species becomes extinct. Living and stable species are therefore found to be organized in such a way that their persistence and perpetuation are ensured by all kinds of structural, chemical and behavioristic peculiarities and devices. These are usually called "adaptations," especially in those cases when some special feature of the environment is provided against: thus low temperature in the surroundings is countered in mammals by special thickness of fur; scarcity of food is compensated for by the special development of senses, intelligence and activity, as in most carnivorous species; enemies are thwarted by protective structures and modes of behavior. To particularize is unnecessary, since we are now interested in the general rather than the special character of living beings. In all such cases the adaptation represents a condition which favors the persistence of the vital equilibrium—something which enables the individual or the species to survive, especially the species, since cases are numerous where individuals are sacrificed to secure the survival of the species.

In general what we mean by an "adaptive" feature in an organism is some special peculiarity of structural organization or activity that directly aids in preserving the organic equilibrium, *i.e.*, in securing survival. A few concrete examples of internal and external adaptations will illustrate. The arrangement of the valves in the heart is adaptive, since it ensures the constant flow of blood in one direction and hence the constant supply of food and oxygen needed to maintain the cells composing the organism. The camera structure of the eye is adaptive in enabling the animal to react effectively to the stimulus of light waves reaching it from different directions of space—these light waves being indicators of the presence and situation of physical objects which are thus discriminated. A countless number of special adaptive structures and habits have reference to the special features of the animal's environment: arboreal creatures have special clinging devices; parasites are curiously protected; predatory animals are usually swifter, more powerful and more intelligent than their prey; the special instincts of an animal are its congenital adaptive modes of behavior. In brief, unless a character in some way definitely furthers continued existence in an environment it is not classed as an adaptation; its criterion as adaptation is that it favors the persistence of the species. To put the matter concisely, adaptation is a form of equilibration. This characterization expresses of course only the most general significance of adaptive characters and neglects the infinitely various details.

Physiological science is not yet in a position to account for the development of the special mechanisms involved in the adaptive actions of organisms, or even to explain their mode of operation in their finished and active state as parts of the adult organization. Thus there is still uncertainty about the mechanism of muscular contraction (although the indications are that a muscle is an electro-capillary motor); and everywhere similar difficulties confront us. These arise chiefly from the unexampled complexity and delicacy of living structures and mechanisms, whose characters furnish at once a support to vitalists (like Haldane and Johnstone), and a challenge to the mechanists, who see in the regularity of vital action a proof of its complete conformity to physico-chemical law. It would seem, however, that the *scientific* difficulty is mainly one of analysis and will become less with time and the progress of research. Probably the chief reason why the structural features, chemical properties and activities of organisms are so remarkable and so difficult to duplicate in artificial systems is that the material composing the living organized structures is always *metabolizing* material, of the kind characteristic of life. Structures which would be impossible (because impermanent or unstable) in material having no such automatic power of self-replacement are capable of permanent existence in living organisms; hence the possibilities of organized structure and activity are enormously increased. The structural organization present in the nervous system of a thinking human being is of a type whose stability is rendered possible only through the ceaseless metabolic activity of the living substance, in which the tendency to reach static equilibrium is continually offset by new construction. Regularly acting mechanisms which otherwise would be too delicate and complex to have more than an evanescent existence are thus rendered permanent; and with their continued existence and operation possibilities of activity are introduced which would otherwise be unattainable. Such possibilities are indefinitely great, and correspondingly the capabilities of a highly developed and trained nervous organization have no assignable limits.

These considerations make it clearer what kind of a system,

in the physico-chemical sense, the living organism represents. Evidently the constituting elements or essential distinguishable components of a living organism—considered as a system in equilibrium with an environment—are only in part static conditions; they consist largely of events, processes and sequences, often prolonged and highly complex. The phenomena of life show in a most striking manner how temporal processes or successions of processes can be organized into stable groupings or equilibria, just as certainly as can static conditions. Take an elementary instance: in a human being the swallowing of food initiates a sequence whose details are largely known to physiologists; upon the regular succession of interconnected events and processes which follow, constituting digestion, absorption and the rest, depends the continuance of the individual life. The first stage of the total sequence determines the final and intermediate stages, in a manner which is none the less constant and dependable because it is indirect; if the normal sequence be deranged, the organic equilibrium is disturbed and death may result. Such an illustration indicates clearly the kind of organized or equilibrated whole which an organic individual represents. A still more striking illustration of the living or organic type of constitution is seen in the regular sequence of developmental processes connecting one generation with the next; the continuance of the species in nature depends upon the regular repetition of this sequence. Yet in spite of the inconceivable complexity of the process of embryonic development, it is a perfectly definite, constant and unified process, of such a kind that when its initial event is determined (in fertilization) the whole sequence is also determined. Of course such a sequence may be modified or interrupted by outside agencies; normally, however, it represents a characteristic "natural constant" for each species, and is an essential factor in its continuance, *i.e.*, in preserving its equilibrium with external nature. Such an example illustrates perhaps more clearly than any other the essential nature of vital organization; it is an organization or integration of *processes*. There is no limit to the complexity of the single processes, provided their constancy is assured; and also no limit to the complexity of the integrated product, the living organism. Apparently there exists a popular impression that when consequences are indirect and require time for their appearance they are less certain than if they are direct; the above instances show that they are no less certain; the difficulty is to trace the intermediate events and their interconnection. Highly indirect consequences of the most perfect uniformity and reliability are frequent, one might say the rule, in living organisms. And it is as an organization of processes which are equilibrated, *i.e.*, so interrelated and integrated as to secure persistence and unity to the whole living system in its environment, that life occupies its unique position among the phenomena of nature.

Many of the most characteristic manifestations of life in nature are referable to the innate tendency of living matter, as growing or self-multiplying material deriving sustenance from outside sources, to increase indefinitely in quantity. The limit to this increase—supposing other conditions, like temperature, to be favorable—is set by the supply of available transformable material; presumably if all substances were equally assimilable, the whole of nature might thus be transformed into living protoplasm and the products of its activity. Coal fields and tropical forests are illustrations of how far this process has extended at certain times and localities; and in a somewhat different sense the transformation of the world through human activity illustrates the same tendency.

Since each organism transforms the materials that it assimilates *specifically* into its own kind of living organized system different from others, the inevitable result follows that those organisms which are most effective in securing and transforming these materials increase at the most rapid rate. If we put a yeast cell into a solution containing sugar and the appropriate salts, in course of time these substances are transformed into yeast protoplasm; if several cells of different species are introduced, several different kinds of protoplasm are produced, in quantities determined by the relative transformative or metabolic capabilities of the species. Such facts indicate that whenever organisms are present a tendency results for all assimilable compounds in the environment to be transformed into living substance; and there seems to be no doubt that here actually exists in nature a general tendency of this kind, however it may be interpreted philosophically. To physical science this tendency appears simply as a necessary result of the property of automatic growth and propagation characteristic of protoplasm. This peculiar appropriative property of life, which is apparently an accident of the special chemical constitution and structure of its physical basis, introduces into living nature the element of competition or struggle, which since Darwin's time has been recognized as a main factor determining the direction of organic evolution. Only those organisms can persist in free nature which possess the means of securing the material and energy required for their maintenance and increase; accordingly, since the supply of transformable material is limited, the characteristic situation arises which is described (in anthropomorphic terms) as the struggle for existence, with its result, the survival of the fittest. It is curious to see how what appears to physiological science simply as an automatic activity of systems possessing a certain physico-chemical constitution has resulted in the spread of life over the whole earth, with all of its extraordinary diversification. The original appearance of life might thus conceivably have been due to some primarily accidental collocation of materials, producing a system having the power of automatic specific transformation and growth. Any such system having thus arisen would inevitably persist and spread, provided the substances and physical conditions necessary for its growth were present. For example, the production, through some chemical accident, of a photochemical transformer like chlorophyll would enable the organisms possessing this compound to spread wherever there was a supply of carbon dioxide, salts and water. We observe in fact that green plants cover the whole earth, and that the greater part of organic life is directly or indirectly dependent upon them.

There is an apparent quality of exclusive self-reference in all organisms, due to the specific assimilative element in their constitution. This fact is in no way inconsistent with the development of interdependent relations between the individuals of a species, as seen in the social animals, or even between different species, as in symbiosis. Such conditions may be regarded as forming the physical basis on which altruism has evolved in the higher forms of life; it should be noted, however, that they can persist only in so far as they favor (or at least are compatible with) organic survival. What we describe as the egocentric property of conscious organisms appears to objective science simply as a manifestation of the characteristic vital assimilative capacity, which, being specific for each organism, has the effect of making each act as if it were the expression or objectivation of a definite "purpose," that purpose being to maintain and multiply itself and its own species. At least it is objectively true that unless the organic activities have this result in the long run, extinction follows, as a purely physical consequence. No one can ascribe selfishness, except by metaphor, to a weed which chokes out all the fairer plants in its neighborhood; and yet the property which such an organism exhibits, and which is physiologically necessitated by its own innate type of constitution, has an obvious resemblance to the conscious and acquisitive selfishness shown by human beings under certain conditions. The curious and seemingly inexplicable dependence of consciousness upon the physiological processes in a particular single organism—what we call personal consciousness—is a phenomenon which gives to the intellectual and psychic processes, so highly developed in man, the appearance of being essentially biological functions, developed like other functions in the interest of organic survival. The selfishness of persons, social groups and nations would thus appear as something rooted in the

elemental physical nature of organic life, and hence inescapable. But this view has its limitations, and need not disturb those who still believe in the possibility of transforming life and nature in the direction of realizing or objectifying the higher human ideals. Such ideals have a reality, a fundamental part of which is the physical reality of living beings; hence they have transformative and reproductive capacity—*i.e.*, the potentiality of indefinite multiplication and self-realization which is inherent in all life is theirs also. The qualities of the best life are thus capable of survival, increase and eventual dominance, equally with those of inferior life—probably more so, since all persistent life requires the maintenance of equilibria, and equilibria are more stable when disharmonies, destructive elements and other incompatibilities are absent.

So far I have been considering life as a development or special derivative of physical nature, and have dwelt chiefly on its physico-chemical properties and aspects. But these form only a part of its total reality; this is shown clearly by our own conscious experience. Many other sides of our problem would require consideration in a complete discussion; but time does not permit of this, and I am also not sure of my qualifications for the task. There are, however, certain more general considerations which I wish to bring forward, necessarily in a somewhat summary form, as having an intimate bearing on the more fundamental aspects of our problem.

Observation seems to show that the living organism, as a part of nature, exhibits all of the general or fundamental characters of natural existence, but in an intensified and centralized form; *i.e.*, the organism is an epitome or summarized expression of certain essential and innate properties or peculiarities which pervade the whole natural process. The complexity, specialization and diversification of living beings correspond to certain definite natural tendencies carried to an extreme; similarly with their spontaneity and originative or creative capacity. How then are we to interpret nature as a whole? A true interpretation would enable us to comprehend the two apparently contradictory aspects of organisms, (1) their physically determined or mechanistic character, existing in combination with (2) their apparent freedom of action and creativeness, the latter being seen especially in human beings. At present among biologists the mechanists and the vitalists form opposed groups; yet it seems certain that there is no necessary or irreconcilable contradiction between their views. A free or purposive agency may be mechanically actuated, *i.e.*, may exhibit complete mechanical interdependence between all of its parts and processes; nevertheless in its ultimate determination other factors than the mechanical may enter. It still seems to me that the case of an artist working with mechanically refractory material illustrates this general type of situation; he may master his material only in so far as he is familiar with its mechanical properties and behavior, and conforms his own action to these. The material undergoes no change except as acted on by mechanical forces, but these are directed and coördinated by the conscious intention of the artist.

The problem is difficult, and I can do no more at present than to indicate what seems to me the probable direction in which its solution lies. It is a problem for both physical science and philosophy, especially for a philosophy which is rigidly critical and demonstrative in its method, rather than speculative, since our purpose is to obtain a clear and valid conception of the present actuality, rather than to develop ideas which appeal to ingenious and imaginative minds as representing interesting possibilities.

Nature, as it presents itself to our observation, has its highly general or universal as well as its particular aspects. It is at once a continuum and a tissue of separate events. Repetition is its most pervading characteristic, at least when its details are considered. This repetitive character seems fundamental to reality in general; it forms the basis of logic in the mental sphere, and of stability, uniformity and regularity in the physical sphere. Yet the whole natural process does not seem to be repeated (in spite of Herbert Spencer's contention), but has a progress or trend; scientific observation indicates this, and the physical law of dissipation seems inconsistent with any other conception.

We have then in natural reality a combination of a regular or repetitive structure (equivalent to law-abiding or logical) with a forward and apparently irreversible trend or activity ("becomingness") which is perpetually generating novelty. This novelty appears to scientific observation as derived from changes in the configuration, position, and modes of interaction of certain persistent entities or objects whose characters remain unchanging. In the physical sphere these appear as atoms or electrons; the quantum theory also attributes atomism to energy. A diversity or manifoldness arising from the varying combination of similar ultimate elements, *i.e.*, some kind of an atomism, would seem inherent in the natural constitution of things.

Now physical atomism seems to be related to the general characteristics of space and time. Just as one portion of space or time is similar to any other, so any condition originating in space and time is persistent and unchanging only in so far as it conforms to this general characteristic of spatiality and temporality. Hence the electrons, *i.e.*, the ultimate persistent or unchanging spatio-temporal elements of physical reality, are all alike; *e. g.*, all electrons are equal in the physical property of mass or inertia, a quality defined by a relation, *viz.*, acceleration, dependent on fixed spatial and temporal conditions. Thus there exists in nature a stable, unvarying or permanent foundation on which development can proceed. No development, but only chaotic conditions, would be possible without an underlying permanence and stability in the ultimate constitutive elements of physical reality and in their mode of action. On this much it would seem that all scientifically and logically trained minds can agree.

The repetitive and orderly quality everywhere observed in nature is a derivative of this foundational stability. And this quality, shown in external nature as the natural laws or constants discovered and formulated by scientific observers, has its close correlative in the repetitive and orderly quality of conscious intellectual operations. These, whatever else they may be, or implicate, *are* a factor in enabling the living organism to deal effectively with external nature. All human experience shows this. Knowledge is a relation of correspondence between the knower and the thing known; there is an adjustment which interrelates the two in a manner favorable to the knower, *i.e.*, he is thereby enabled to act effectively in reference to the thing known. This kind of relation is similar to that observed in external nature between the organism and the environmental objects to which it reacts effectively. The element of adaptiveness or equilibrium is the essential feature in this relation. It would appear, therefore, that the orderliness in both the mental and the physical domains has a common origin and significance. The question of the ultimate basis of this "logical" quality in things is, however, one for metaphysics rather than for natural science.

But there is also in nature an element making for the production of novelty—a creative or synthetical ingredient; this introduces complexities which to our minds often appear as disorder and arbitrariness. Many origins seem at first sight unaccountable; yet when they are traced out in detail they are found to consist of orderly and familiar elements in new combinations. Their discordance or alien quality seems usually due to lack of conformity with other systems or processes which have arisen independently—*i.e.*, to lack of equilibration. This incompatibility gives the appearance of disorder in nature, and indeed is disorder, in the sense that anything *new* necessarily lacks conformity to established rule at its first appearance; but, given time, all existents which are in free communication settle down into some kind of equilibrium or *modus vivendi*—at least this is true in the physical world. Whether it is true of existence as a whole may be doubtful;

the element of conflict seems ineradicable so long as novelty continues to come into existence, for, *qua* novelty, it necessarily encounters conditions which are not in harmony with it and with which in some manner an equilibrium has to be reached—a process requiring time and mutual adjustment.

This combination of conservative and novel elements in the structure of reality makes a different kind of appeal to persons of different mental constitutions, and is what gives rise to the apparently irreconcilable feud between the mechanists and the vitalists in biology. Those men who are most impressed with the essential conservatism and constancy of natural processes as exhibited in the living organism are mechanists; to them the organism is simply a complex machine. Those who are chiefly conscious of the free and novelty-engendering element always present, and most conspicuously in those activities that seem characteristic of the highest vitality—*e. g.*, originality and creativeness in art—are vitalists; such men are often inclined to limit the applicability of physico-chemical methods in physiology. On our present view both are right and both are wrong; the organism in its purely physical constitution is undoubtedly a physico-chemical system, peculiar in nothing but its special qualities of complexity and highly developed specificity; yet to account for its complete characters a reference to ultimates other than the physical seems necessary.

This last consideration is the crucial one. For example, if the regular or conservative tendencies disclosed by natural science were the only ones operative in nature, it would be incomprehensible why the universe is not homogeneous, or at least is not in a state of settled and stable equilibrium, since sufficient time has elapsed for any inequalities of potential to have become equalized, and thus to balance one another wherever they come in contact. The fact that this has not happened indicates the presence of some constantly acting originative tendency in nature which in some manner compensates the tendency toward a static equilibrium.

The scientific, mathematical or logical description of nature does not pretend to exhaust the concrete detail of reality; nevertheless it undoubtedly expresses accurately many of the permanent conditions to which all phenomena (all existents?) must conform. These permanent conditions are the primary or fundamental actualities in nature; and they underlie and make possible the infinite variety of materials, events, processes and developments which it presents to our observation. All of these, except possibly the most elemental realities investigated by mathematics and logic, appear as products of what we may agree to call "creative evolution." This process is also a fact, a tangible actuality in our experience. To call the novelty-producing or creative element in reality "volitional," or to ascribe to it consciousness, purpose and ethical intention, is in a sense to anthropomorphize nature; in any case it can give only a vague indication of the essential nature of the originative factors underling development. Still, these factors, if existent in a natural product like humanity, must also be present in some form in the natural process considered as a whole. In all such speculations, however, the implications of language are misleading; and direct experience or intuition of phenomena—in active life as well as in observation and reflection—would seem to be the safest basis for sound and valid thinking. Of course by the term intuition I mean nothing mystical or indefinable, but simply direct conscious experience of the actual phenomena of life and nature, without the prejudices or preconceptions arising from the use of words or other symbols. Scientific observation or intuition (in this sense) discloses as a reality the constant or law-abiding and hence calculable element in phenomena; but superposed on this, and equally real and fundamental, is the creative element which gives nature its character as a temporal or historical process whose possibilities are never completely realized at one time, but always in process of realization. The conflict of opinion which makes metaphysics an alien and often unsympathetic field to students of the physical sciences indicates that something is still lacking in our knowledge of the essentials of reality. There must be some solution of the metaphysical problem on which all clear-sighted, honest and disinterested minds can agree.

THE ART OF PROLONGING THE LIFE OF PLANTS

The dearest dream of mankind for untold ages has been the cheating of death. The fountain of youth has been sought for century after century even more eagerly than the philosopher's stone. Eminent scientists from Roger Bacon to Dr. Voronoff have busied themselves with the problem and startling results have been obtained in the last decade by various methods, including the grafting of certain organs, the use of the X-rays, etc.

It is our present purpose, however, to describe the success obtained by the eminent Viennese botanist, Prof. H. Molisch, in prolonging the life of plants. This authority announces that the duration of the life of a plant can be increased in various ways. The simplest method of accomplishing this consists in retarding germination by depriving the plants of certain conditions requisite for sprouting, such as moisture, warmth, oxygen, etc. In this manner seeds can be made to retain their vitality for not less than sixty years and bacteria for much longer. This interesting fact explains the apparently well authenticated cases of a sudden outbreak of the mediaeval plague in modern times.

It is also possible to lengthen the existence of those plants which bloom only once throughout their life by preventing the bearing of blossoms and fruits. A case in point is the American Agave also called the hundred year-old aloe or commonly the century plant. In its Mexican home this plant requires only eight or ten years to become mature enough to blossom, whereas in less appropriate climates, i.e., in a temperate zone, it needs fifty years or more to accumulate the substances which it has need of in order to produce flowers. Thus in this case also the life of the plant is greatly extended. For the same reason the *Reseda odorata*, which ordinarily is an annual, may be made to live for two or three years merely by suppressing the blossoms. This explains, too, why close-clipped turf can be kept fresh and green for many years. Another example of interest to garden lovers is the well-known fact that many annuals can be made to live for almost two years if they be sown in the fall instead of in the spring.

But besides these ordinary and somewhat obvious methods of prolonging the life of plants, more strenuous measures may be taken by the forcible alteration of the activity of one of the plant's organs. For example, the leaf stem of the *Begonia rex*, which ordinarily dies at the end of a year together with the blade of the leaf, may be prevented from dying if the leaf be used as a cutting. In this case leaf sprouts develop from the blade of the leaf and the former leaf stem becomes transformed into a stalk and continues to live for two or three years longer. Extensive investigation has proved that in such a case the internal structure of the leaf stem undergoes an extensive alteration fitting it to perform its new function; for instance, the sap channels become greatly enlarged. In a similar manner it is possible to maintain the vitality of the flower stem, which ordinarily quickly perishes. It is a notable fact that in many cases the dying of a cluster of flowers is retarded by the action of gall-forming insects which make their homes therein; this may be observed in the catkins of certain oaks attacked by gall.

Fruit raisers thus prolong the life of their trees:

A short-lived variety is grafted upon a long-life variety, thus assuring an extension of life in the case of the transplanted scion. Sometimes, indeed, the reverse of this may be observed, i.e., a prolongation of the life of the grafted tree by means of the scion. All these facts deserve attention and further study both from scientists and agriculturists, since they are of tremendous importance in both gardening and farming and furnish rich possibilities of advantage in all such matters.

So-Called Lung Fishes

Peculiar African Fish That Buries Itself In the Mud During the Dry Season

SINCE by far the great majority of fishes obtain the oxygen they require not directly from the open air, but from air dissolved in water, they breathe through gills. Gills are rows of red fringes, into each strand of which there runs a blood vessel. As the water passes over it the dissolved oxygen is absorbed through the skin of the gill fringes. The gills are attached to the gill arches, which are four rib-like bones on each side of the gullet above its entrance.

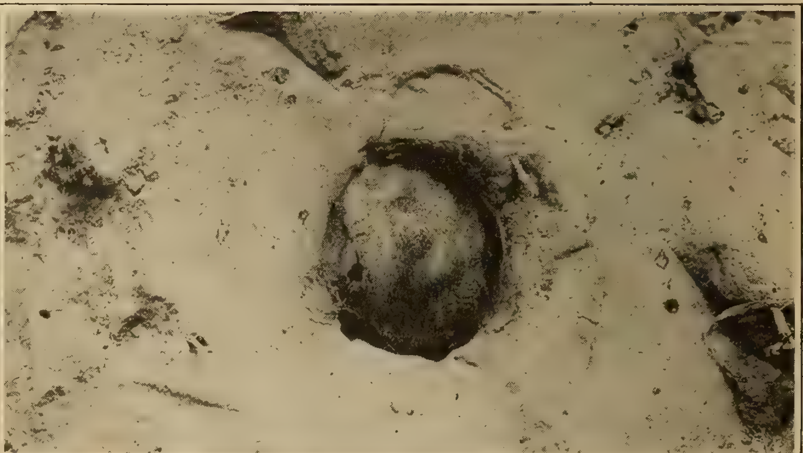
But there are some curious fishes found in various parts of the world which possess lungs as well as gills and, therefore, are called lung fishes or *Dipneusti*. In this subclass the air bladder is of a cellular nature and is used as a lung. The layman might readily suppose that these air-breathing fishes are a more advanced type than their gill-breathing brethren—a type farther along the road of evolution. Such, however, is not the case. They are, on the contrary, very ancient of origin, coming down to us from "the vast darkness of Palaeozoic times."

In the *Dipneusti* the trachea or air duct starts as in the higher vertebrate animals from the lower side of the gullet. But in some more specialized fishes it is transferred from the ventral to the dorsal side to avoid making a turn in passing around the gullet itself.

In all the *Dipneusti* or *Dipnoans* as they are sometimes called, there is but one external gill opening, leading to the gill arches. In the young there is a bushy external gill. The nostrils, as in the frog, open into the pharynx, while the heart is three-chambered, the arterial bulb having many valves. The cellular structure of the skin and other tissues is essentially similar to that found in Amphibians. While there are a number of species we shall here confine ourselves chiefly to the African Lung Fish of which we are able to present excellent photographs, and to the Australian fish known as the barramundi. This latter fish sometimes reaches a length of six feet and is highly valued as food. Queensland settlers often call it salmon, from its pink colored flesh. The barramundi is conveniently able to use the gills and the lung either together or separately. It is said to be in the habit of taking occasional promenades on land, but there is some doubt about this. We are indebted to the Royal Natural History, edited by Richard Lydekker, B.A., F.R.S., etc., for much of the information in the following paragraphs, but our photographs were obtained through the courtesy of the American Museum of Natural History, New York City:

In the lung fishes the skeleton is partially ossified, with well developed membrane bones; the gill clefts are but slightly separated, and open into a single cavity protected by an external cover; and the external skeleton consists of true bony tissue. In the existing members of the group the optic nerves (or those proceeding from the brain to the eyes) simply cross one another, without any interlacing of the constituent fibers; the intestine has a spiral valve; the air-bladder is elongated and performs the functions of a lung; and the nostrils open posteriorly by two apertures into the cavity of the mouth, after the manner of the higher vertebrates. The membrane bones covering the roof of the skull, which are very few in number, cannot be correlated with those of the bony fishes. The lung fishes are at the present day represented only by three genera, with but very few species, but they were formerly a very numerous group, which appears to have been on the wane since a very early epoch.

The three existing genera of lung fishes may be taken as the typical representatives of an order including several extinct



MUD FISH COCOON EMBEDDED IN A MUD BANK

HOW THE MUD FISH BURIES ITSELF

THE MUD BALL BROKEN OPEN AND SHOWING THE COCOON

families, and known as the Sirenoidea. Its essential characters are that the head is covered with membrane bones; that the main dentition takes the form of large grinding plates, situated on the pterygoid bones in the upper, and on the splenials in the lower jaw; that the body is covered externally with overlapping scales; that the notochord persists throughout life; that the paired fins are of the fringed type;

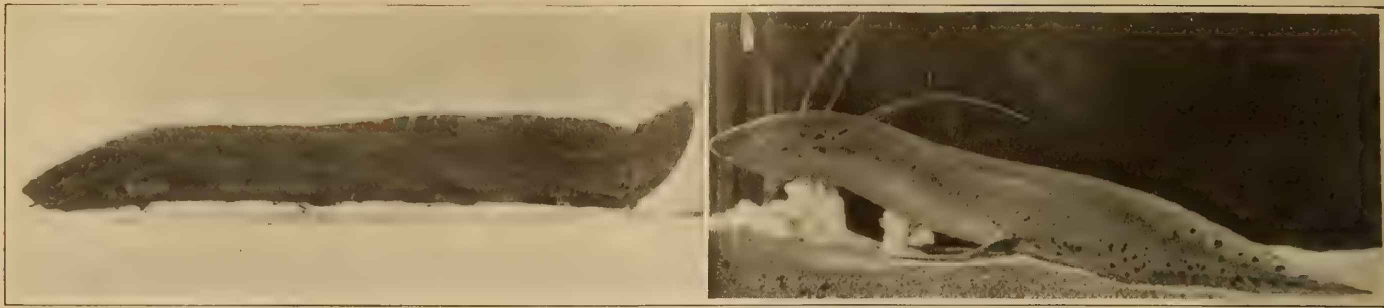
CASE CONTAINING MUD FISH COCOON FROM GAMBIA, WESTERN AFRICA

and that none of the fins are armed with spines. The existing forms have but few membrane bones to the skull; no premaxillæ, marginal teeth, or jugular plates; a fringed tail, furnished with a continuous vertical fin; and cycloid scales.

Australian Lung Fish.—For a great number of years there were known from the Triassic strata of various parts of Europe fish-teeth of a remarkable type; from the fancied resemblance to a deer's antler, presented by these teeth, the name of *Ceratodus* was suggested for the otherwise unknown fishes to which they pertained. Similar teeth were subsequently obtained from Secondary Rocks in India and also in South Africa, but it was not until the year 1870 that a fish was discovered in Queensland having teeth of a similar type. Known to the natives, in common with other large freshwater species, by the name of barramundi, the Australian lung fish (*C. forsteri*) agrees so closely with the extinct forms that it is usually regarded as generically identical. Its mouth is furnished in front with a pair of chisel-like teeth situated on the vomers, behind which comes a pair of palatal teeth of the type of the one described, but carrying six complete ridges, and an incomplete seventh; while there are a pair of similar teeth in the lower jaw, carrying only six ridges each. In the living species the teeth of opposite sides are separated by an interval; but in the fossil forms they were in contact, and had fewer ridges. The existing Australian lung fishes, of which two species have been described, are said to attain a weight of 20 pounds and a length of upward of 6 feet. The body is elongated and much compressed, with very large scales; the paddle-shaped limbs have very broad fringes; and the flesh is salmon-colored. From the occurrence of masses of leaves in its stomach it is evident that the Australian lung fish crops the vegetation with its great teeth; but it is believed that the most important part of its food consists of the small creatures living on and between the leaves of the various water plants. The stories of the fish coming out of the water to the land seem quite unfounded, as are those that it lies dormant during part of the year in cocoons. The female lays her rather large eggs loosely and singly among the vegetation, and in the embryo the fore-limbs make their appearance in about a fortnight, but the hinder part not before two and a half months. In the course of the development this fish presents marked resemblances to the Amphibians, and also to the lampreys; but it is noteworthy that there is no trace of a sucking mouth, or of external gills. As might have been inferred from the study of allied extinct forms, the large palatal teeth are formed by the fusion of a number of separate small teeth. According to Dr. Semon, the Australian lung fish is confined to the middle portion of the Burnett and Mary Rivers of Queensland. Living among the mud and leaves at the bottom, it rises at intervals to the surface to obtain more complete oxygenation of its blood by the inhalation of atmospheric air into its lungs, although its general breathing is carried on by the gills. A grunting noise sometimes uttered by this fish is probably produced by the expulsion of the air from the lungs when it rises to the surface. Although frequently termed the barramundi—a title apparently belonging to a totally different fish (*Osteoglossum*)—it appears that the proper native name of the Australian lung fish is djelleh. The breeding season is at its height in September and October, but lasts from April to the beginning of November; and the eggs which are enveloped in a gelatinous coat, and are heavier than water, take some ten days to hatch.

African Mud Fish.—The African mud fish (*Protopterus annectans*), widely spread over the tropical regions of the continent from which it takes its name, differs from the last in that the filamentous fins retain a small fringe containing rays; as well as in having six gill-arches, with five intervening clefts, while there are three small tentacle-like appendages above the small gill-opening on each side. In the Gambia River, where they are very abundant, these fishes are in the habit of burying themselves during the dry season, making a kind of nest, in which they pass a period of torpidity. Here they may remain for the greater part of the year, only resuming their normal aquatic life with the return of the wet seasons. Prof. W. N. Parker, who received some specimens in the torpid condition, writes that about a hundred individuals were dug out and packed up in crates still enclosed in the clods of mud. On arrival in Europe the clods were opened,

CHISELLING THE COCOON OUT OF THE EARTH BALL



MUD FISH IMMEDIATELY ON EMERGING FROM ITS COCOON (*LEFT*) AND AFTER ASSUMING ITS NORMAL FORM (*RIGHT*)

and the fishes placed in a tank in a hothouse. The statement of the natives that the species grows to the almost incridible length of 6 feet suggests that it must be a very long-lived creature. From the above-mentioned specimens it was found that these mud fishes grow very rapidly, have great vitality, and, although able to sustain fasts, are exceedingly voracious, devouring all the snails, earth-worms, and small fish given them, and then killing and eating each other, making it difficult in the extreme to preserve the specimens. They are most active at night, and appear to keep mostly to the shallow water, where they move deliberately about on the bottom, alternately using the peculiar limbs of either side, though their movements do not seem to be guided by any strict regularity. Gray has compared these movements to those of a newt, and several other observers have noticed them. The powerful tail forms a most efficient organ for swimming rapidly through the water. It is a well-known fact that this fish comes to the surface to breathe at short intervals, and thus it is evident that the lungs perform an important, if not the chief, part in respiration during the active life of the animal. The air passes out again through the opercular aperture, and the movements of the operculum itself indicate the fact that branchial as well as pulmonary respiration takes place. Externally, the sexes are alike. As in the American species external gills are developed in the young. As regards the breeding-habits of these fishes nothing very definite is known. It is stated, however, that the numerous eggs and embryos are carried about in an elongated gelatinous pouch attached to the sides of the back of one of the parents, although the sex in which these receptacles are developed does not appear to have been ascertained. In conclusion, it may be observed that Professor Parker is of the opinion that although the lung fishes present certain resemblances on the one hand to some of the sharks and ganoids, and on the other to the lower Amphibians, yet they appear so distinct from both that he thinks they ought to be removed from the fishes to form a class by themselves.

FLORAL FIREWORKS

The methods by which plants secure the distribution of their seeds and spores, so as to give their offspring a better chance to get on in the world than if they stayed too close to the parent stem, are always interesting and sometimes very ingenious. In a number of cases one sort or another of ballistics is employed to secure the discharge of the seed with considerable violence, thus giving it a good start on its travels by windpower. In the accompanying illustration we show a remarkable instance of this. As the reader can see the photographer was lucky enough to catch the puff ball at the very moment of its explosive discharge of its spores. These lycoperdons are among the most familiar of the fungi common to Europe and America. The explosive action in this case is due to the sudden splitting of the outer skin of the fungus because of the pressure of the humid spores within, which are expanded by the rays of the sun falling upon the plant. It is said that those persons with a delicate enough sense of hearing can even perceive the noise of the explosion when this vegetable bomb goes off.

Many other plants discharge their seeds with more or less violence, with the same object of propelling them to as great a distance as possible. The common touch-me-not found in all old-fashioned gardens is a well-known example of this. When the pods of peas and beans become dry, they undergo a torsion which secures their dehiscence.

Various forces are operated in securing the forcible ejection of seeds and spores; the movements by which the discharge is accomplished are sometimes occasioned by cohesion, sometimes by hygroscopic phenomena, and sometimes by turgescence as in the case of the lycoperdon.

Those motions in which an external factor directly induces any movement of any part of a plant are called by botanists, paratonic movements, or more simply, stimulus movements. In the touch-me-not cited above the seed pod consists of narrow segments united at the tip, and in such a state of tension that a mere touch causes them to separate at the tip and curl up into a convexo-concave shape. Other stimuli besides this one of contact are light, heat, gravity, and various material and mechanical forces.

The geranium family have pods composed of five carpels of a beak-like form which generally open to liberate the seeds; sometimes, however, the pod itself remains closed and the awn-like portion of it goes through a series of hygroscopic movements, whose object is to bury the seed in the soil.

PUFF BALL EXPLODING AND DISCHARGING ITS SPORES

The Mechanical Side of Evolution*

Some Remarkable Recent Discoveries in the Field of Embryology

By Dr. A. Weber

Professor of Anatomy in the Universities of Algeria and Geneva

In the following article by Dr. A. Weber, who is himself a well-known original investigator along these lines, an excellent résumé is given of the remarkable advances made by this science during the last six years. The article is too long to publish in full in these pages; we shall, therefore, omit the more technical portions of it appealing especially to professional biologists and confine ourselves to the reproduction of the introductory paragraphs together with those sections of general interest, giving merely a brief résumé of the first six sections.—The Editor.

In the *Revue General des Sciences* for October 15-30, 1914, we called attention to the critical period through which the science of embryology was passing. The rapid development of this science was due principally to the enthusiasm created by the spread of the theories announced by Darwin and by Haeckel. Many investigators believed that the question of the origin of species found its solution in embryological discoveries. These attempts to fathom the past history of living creatures justified the almost unanimous belief in what is known as the *fundamental biogenetic law* or law of Haeckel: *i.e.*, that the development of the organism follows the history of the development of its species; in other words that ontogeny recapitulates phylogeny.

It was long ago clearly demonstrated by paleontologists, Depéret, among others, that many embryologists had confounded the phylogenetic development of species with that of organs considered separately. It has been oftenest among species unrelated to each other as a matter of fact that it has been found possible to establish in this manner the evolution or the involution of portions of the skeleton or of the viscera.

The critical comments of such embryologists as O. Hertwig, Keibel, and Vialleton, indeed, have practically torn to shreds the aforesaid fundamental biogenetic law. Its almost unanimous abandonment has left considerably at a loss those investigators who sought in the structure of organisms the key to their remote origin or to their relationships. Although that future opinion may be less positive with respect to the phylogenetic value of embryology. After all, as Hertwig observes, the reason why we now class the Sacculina, a parasite of the Crab, among the Crustaceans, is solely because of the study of its development.

It appears to be a fact also that embryological researches have been influenced by the new direction taken by concepts of heredity. The wide spread extent and the success of the experiments undertaken in order to verify Mendel's laws of heredity have been of no little help in creating an entirely new attitude among embryologists. It is practically certain that purely descriptive embryology has now yielded the major part of the knowledge that can be expected from it. It is above all an analytical process in the service of Comparative Anatomy. However the information it furnishes with respect to the homologies and analogies of organs or their functional adaptations, and to their physiological or morphological values is of interest. On the other hand a new form of embryology has recently made its appearance. This science is what the Germans term the *mechanics of evolution* and what Brachat calls *causal embryology*. From this new point of view investigators no longer devote themselves to explaining the past history of organisms but rather to exploring the present causes of their development. Thus what embryology has lost from a speculative point of view it has undoubtedly gained in precision by following the modern method of research.

This review will be concerned principally with the recent works inspired by this new attitude of mind. The largest number of these works has appeared in the German language. Professor Roux was one of the first men of science to adopt this new viewpoint and he has carried with him many of his students. The periodical in which most of their experiments have been reported, namely, *Archiv für Entwicklungsmechanik der Organismen* (Archives of the Mechanics of Development of Organisms) did not cease publication during the war. While nearly all of our French scientific journals failed to appear, the Germans continued to exhibit but slightly diminished activity; for while the war was a matter of life and death to us, it was to our enemies merely a matter of business.

Such considerations enable us to comprehend how the scientific value of Brachet's work *L' oeuf et les facteurs de l'ontogenèse* (The Egg and the Factors of Ontogenesis) is increased by its moral success. Brachet, professor of anatomy at the University of Brussels, who took refuge in Paris after the invasion of Belgium, edited and published in 1917 the remarkable series of lectures given by him at the College de France. This admirably documented little book is at once an excellent résumé of the principal researches with regard to Causal embryology, and an excellent point of departure for new researches in their varied directions.

In the following lines we shall make use of this book as a guide in the analysis and classification of works dealing with the factors of ontogenesis.

I. Agamous reproduction and sexual reproduction

In the beginning of his book Brachet sets forth the analogies and the differences between sexual reproduction and nonsexual or agamous reproduction. . . . It appears to be true that sexual reproduction is conditioned either by an abundant and durable nutrition, a rapid growth and an extended life, or inversely perhaps by variations of the temperature or chemical alterations of the milieu and of the nutrition. The identical results of these contrary influences is due to a mechanism whose discovery is very recent, namely, *physiological isolation* of the portions of an organism, it being only requisite for an organ to escape to the dominating correlations of the other organs to become capable of revealing latent powers such as those of *reproduction* or *regeneration*. . . .

The principal authorities quoted in this section are C. M. Child and E. Rabaud.—Editor.

II. Conditions of fecundation

This section discusses the question of Polyspermia, the principal authorities quoted being A. Brachet, M. Herlant, F. R. Lillie, and Bataillon.—Editor.

III. Physiology of the egg

Under this title Brachet examines the present state of our knowledge with respect to the characteristic manifestations of the life of the egg cell which has arrived at maturity. This cell dies unless the phenomenon of fecundation or some similar

*Abstracted and translated for the *Scientific American Monthly* from the *Revue Generale des Sciences*, December 15 and 30, 1919.

phenomenon occurs. As Fauré-Frémiet expresses it, the egg which has arrived at the state of equilibrium which constitutes maturity is in a state of latent life; when left to itself it undergoes a sort of "agony" which is the more prolonged the less oxygen it is in contact with.

Many cytologists, including R. Hertwig, Popoff, and Child, have compared the mature egg to those infusoria which are in a state of depression or senility and which are rejuvenated by conjugation. . . . This condition of senility of the egg cell is revealed by an almost total lack of permeability. Fertilization reëstablishes this permeability. In the same way Bataillon has proved that the ripe egg is in a state of osmotic hypertension. The contraction of the egg after fecundation and the expulsion of the perivitelline liquid occasion a dehydration of the egg and a lowering of its osmotic tension.

Furthermore, the expelled perivitelline liquid is charged with débris and particularly with carbon dioxide. In the state of equilibrium of maturity the egg may be regarded as an asphyxiated cell which the act of fertilization enables to rid itself of the toxins it contains. The fecundated egg has once more become permeable and expels the débris accumulated in its cytoplasm. These excreta do not always appear in the form of a perivitelline liquid but are sometimes found also in the membrane of the fecundated egg.

The remainder of this section deals largely with experimental parthenogenesis which has already been discussed at some length in this journal and its predecessor.—EDITOR.

IV. DYNAMIC MANIFESTATIONS OF FECUNDATION

Under this title Brachet analyzes the principal manifestations in the egg which has lost its equilibrium of maturity by reason of the penetration of the male element. . . .

The remainder of this section, which is very technical, discusses among other things the phenomena of dispermia and trispermia, etc. It is illustrated with a number of interesting diagrams.—EDITOR.

V. FECUNDATION AND PARTHENOGENESIS

The chief authorities quoted in this section are Farué-Férmiet and F. McClendon.

VI. SIGNIFICANCE OF SEGMENTATION

The question arises as to the meaning of the segmentation which exhibits itself when the egg begins to develop. This segmentation is merely a dividing up of the egg without any formative value. At this period of the development there is no creation and no displacement of germinal localization. Apropos of this the question suggests itself as to what are the relations of the first plane of segmentation with the plane of bilateral symmetry of the larva.

Brachet's experiments along this line are very remarkable: in the fecundated egg of the frog, whatever the orientation of the first planes of segmentation with respect to the plane of bilateral symmetry, the latter is maintained throughout the entire course of the development.

Segmentation makes no change in the germinal localization. Thus the first stages of the development appear to form a preparation for the ulterior differentiation of the blastomeres by imparting to the cells of the embryo the normal size of the cells proper to each species, doing this by actual transformation of the voluminous egg cell.

Each blastomere which is divided by the segmentation possesses an *actual potentiality*, which corresponds to the part which it plays in the typical development of the embryo. The *total potentiality* corresponds to properties whose existence usually remains unrevealed. This latter potentiality is very variable in different animals; in some it is infinitely small, while in others it is so great that one of the first blastomeres is capable in itself alone of producing a complete larva.

In order that the total potentiality shall exhibit its full effect it is necessary for the blastomere to possess those material resources which are requisite, and it is also necessary that the distribution of these resources shall be so managed as to maintain a state of equilibrium analogous to that of the egg. Thus we may consider that polyembryomy is nothing more than a case in which the actual potentiality and the total potentiality are superposed.

In conclusion Brachet examines various hypotheses with respect to the physico-chemical nature of the germinal localization. In his opinion the term idioplasm is a synonym of the protoplasm of the egg, the type cell of each normal species.

The fundamental protoplasm of the species is transformed in the majority of cells under the impulse of correlations between the various tissues and organs of the living creature. The impression of the correlation, less marked in the sexual products or in those organs which form buds, enables the cellular elements in question to revert to the typical state under the influence of various circumstances.

VII. THE MODELING OF THE EXTERNAL FORMS OF THE HUMAN EMBRYO

In a highly original treatise Mr. Bujard has passed in review all young human embryos known to us, studying them from the viewpoint of their external forms by means of geometrical methods. He begins by describing a certain number of axes and of angles which may be observed upon the young embryos. By a comparison of the various stages of the embryo re-

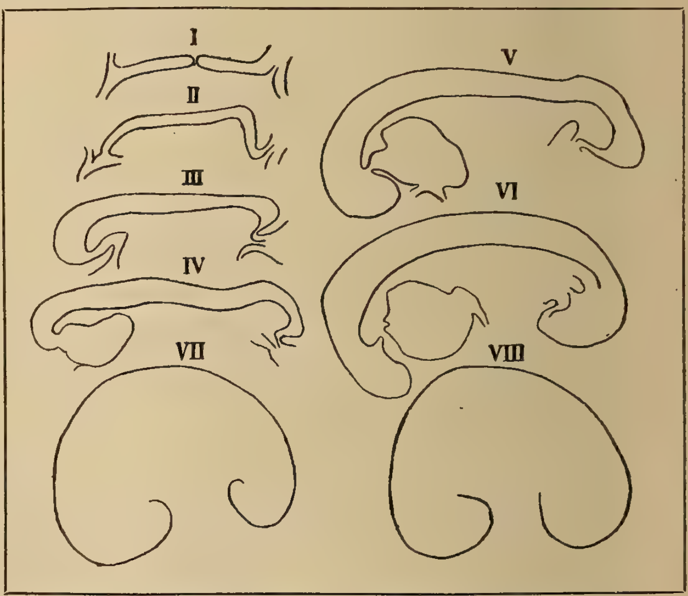


FIG. 1. OUTLINES IN PROFILE OF YOUNG HUMAN EMBRYOS EXHIBITING TYPICAL DEVELOPMENT (AFTER BUJARD)

garded from this point of view, he derives the idea of *embryotectonic curves* (*i.e.*, construction curves) which are characteristic of each of the periods of development. (Fig. 1.)

The study of these curves enables him to apprehend numerous individual variations as well as grave anomalies which, because of the small number of very young human embryos known, have been considered as forming a normal part of the typical stages of the evolution; *e.g.*, the excessive dorsal "saddle-back" of what are known as double C embryos. Thus, the embryo tectonic curves form a criterion which enables us to decide whether any given embryo is normal or abnormal; furthermore, they constitute an expression of the mechanism of the development of external forms.

By means of these curves Bujard has succeeded in analyzing the successive periods of the changing form, or "modeling," of the embryo. During the first period, which is principally a period of growth, the embryonic area expands and grows and the first rudiments of organs make their appearance— the neurenteric canal, the primitive line, the medullary plate, the dorsal cord, and the mesoderm.

During the second period the modeling is very active and the organs assume an individual aspect. At the same time the embryo assumes a spiral form. There is an intense proliferation at the level of the neurenteric canal in the caudal

region. The embryo is thus projected forward; its head describes a parabolic trajectory in space and its tail curves in the form of an arc of a circle around a center which is the point of suspension of the embryo at the level of the origin of the allantoid. At this stage the curve of the back is elliptical.

The movement of forward projection and elongation of the embryo is arrested by the phenomena of the appearance of the rudimentary outline of the heart. The head now assumes a spiral position and this process is propagated by degrees to the dorsal region.

During the third period the spiral torsion of the embryo reaches its maximum, and then the beginning of a movement of deflection makes its appearance.

Furthermore, the examination of these embryotectonic curves enables the investigator to make extremely interesting observations with respect to the comparative topography of the various organs of the embryo. For example, the modeling of the head of the human embryo is accomplished by a series of sliding movements, which gradually bring the posterior skull beneath the pharynx and the branchial region. These sliding movements occasion a gradual effacing of the cephalic somites. Another interesting observation having a general application is that concerning the rhythm which appears in the growth of the embryo—periods of growth follow in regular succession upon periods in which the modeling process is most marked.

VIII. EMBRYONIC GROWTH

The researches of Robertson Brailsford are of particularly great value with respect to the entire evolution of the individual. According to this authority the greatest rapidity of growth occurs when the total growth is about half finished. The work of Bialaszewiez with regard to the embryos of amphibious animals is particularly apropos of the study of growth.

The first stages of the development of amphibious animals exhibit an almost perfect spherical form, whose diameter can be measured with comparative precision. During the first few hours after fecundation this diameter increases regularly and then the animal pole is flattened and the volume of the egg is diminished. At this moment it extrudes perivitelline liquid, a process which corresponds to the dehydration and purification of the cytoplasm of the egg.

Immediately after this occurs the volume of the egg begins to increase again. This growth is particularly rapid during the phenomenon of the gastrulation; when the form of the larva has been constituted, the measurement of diameters must be replaced by the measurement and the weighing of the density. These researches prove that at this stage there is a decrease of volume. Immediately after the hatching, the moment when the larva leaves the membranes of the egg, there is a very rapid growth, which certain observers, including Davenport and Schaper, have connected with a considerable absorption of water. Moreover a portion of the envelopes is utilized to nourish the larva. In the early stages of the development the increase in the volume is produced by the accumulation of water in the cavity of segmentation.

Influence of Temperature.—The manner in which the rapidity of growth of the embryos of Amphibians is influenced by temperature has been especially studied by Bialaszewicz, Chambers and Doms. These researches verify in general, between 10° C. and 20° C., the law of Van t'Hoff and Arrhenius regarding the rates of speed of reaction. Bialaszewicz has found that whatever the rapidity of development under the influence of variable temperatures the quantity of water absorbed by the larva is constant, and this quantity forms a measure of its growth. A rise of temperature accelerates the formation of the blastomeres at the stage of segmentation in the same proportion in which it increases the hydration of the cells. This absorption of water presumably bears a definite relation to the respiratory exchanges of the larva. Furthermore, the increase of temperature occasions a greater permeability of the egg with respect to the surrounding medium.

The eggs of frogs vary in size according to the region of the ovary from which they come. Chambers has subjected various sample lots of these eggs to variations of temperature. The tadpoles from the largest eggs develop more rapidly as soon as they begin to eat and they also resist the high temperature better. The smaller eggs produce larvæ having smaller cells, but these differences of size in the larvæ diminish in the course of their development. On the other hand temperature has an influence upon the cellular dimensions of the tadpole. The higher the temperature the smaller the cells are.

Doms has verified the application of Van t'Hoff's law to the first stages of the development of frogs' eggs. At this time an increase of 10° in the average temperature causes a growth three times as rapid; but this proportion ceases to be verifiable when the tissues and the organs have begun to be formed. Each tissue then reacts in a special manner which is due as much to its own constitution as to its organic correlations; *e.g.* the branchial tufts ramify more abundantly and more rapidly under the influence of a rise in temperature. Cold arrests the production of these appendices.

Among embryos which have been subjected to cold the original liver and kidney are larger than in the case of larvæ which have been subjected to heat; furthermore, differences of structure are found which concern the variable tissues, which explains the aforesaid differences of volume and which shows how the variations of temperature behave differently according to the elements involved; *e.g.*, in the kidney of larvæ which have been chilled it is the lymphoid and conjunctive tissue which is found to have increased, while in the embryos which have been heated it is the active portion, the canaliculæ and the vessels, which are more developed. In the liver of the chilled tadpoles the epithelial elements predominnate, while in the liver of the heated embryos it is the vascular tissue which has the best of it.

IX. THE INFLUENCE OF MECHANICAL AGENTS UPON DEVELOPMENT

Under this head we shall here consider only the phenomena of compression and centrifugal force.

Compression.—The production of anomalous forms or "monstrosities" has often been attributed to the phenomena of compression, but this view, which applies particularly to the eggs of birds, appears to have fallen into entire disfavor. Numerous experiments among various classes of living creatures have proved that the phenomena of compression are capable of producing deformation but not of occasioning profound modifications in the process of development.

Rabaud has considered this question in reference to the production of omphalocephaly, a monstrosity in which the head of the embryo is inserted in the digestive tube, after having been strongly flexed and partly atrophied. Fol and Warynski were of the opinion that they had accomplished this arrangement by compressing the head of the embryo chick. S. Kaestner believes, like the foregoing authorities, that the momentary cooling of the egg undergoing incubation produces an expansion of the yolk which compresses the embryo against the shell. Raband found no difficulty in demonstrating the absurdity of these observations, which are of far too superficial character. By means of carefully planned experiments he has proved that while the compression is capable of causing a retardation of growth (without doubt by interfering with the nutrition and, most of all, with the direct respiration of the cellular elements), still the monstrosity of omphalocephaly never appears under these conditions.

In a general fashion the compression of eggs in a state of development has chiefly been employed with a view to modifying the planes of segmentation of the blastomeres. In those species in which the first blastomeres have a definite destiny it has been of particular interest to disturb the development in this manner and then observe the ensuing results. Morgan

applied these conditions to the eggs of the *Nereis* and the *Ciona;* when the compression of the egg takes place before the first segmentation division, there is no injurious effect, provided the pressure is removed after the occurrence of the separation between the first two blastomeres. But when the compression is continued, the third cleavage of the blastomeres, instead of being equatorial in direction is meridian, like the two first cleavages. The larvæ obtained under these conditions are abnormal, the germinal localizations of the fecundated egg having been partially displaced by this atypical segmentation. A moderate compression does not prevent development of these eggs, but brings about a disturbance in the differentiation of the organs.

Other authorities, Browne and Dederer have likewise verified the influence of compression upon different eggs with respect to the orientation of the divisions of the blastomeres. Girgoloff observed like Rabaud the diminution of vitality in the blastomeres under the action of compression alone. The influence exerted upon the development of the *Ascaris* larva is the more marked the further advanced the segmentation is. When this mechanical action makes itself felt only at the beginning of the development the blastomeres later resume their normal position and the embryo is not malformed.

Compression, like centrifugation, governs the orientation of the spindles of division of the blastomeres. Experiments with respect to the effect of centrifugal force have been chiefly employed in the study of development in order to analyze the material constituents of the egg, to disturb the germinal localizations, and subsequently to observe the development which begins with fecundation.

Centrifugation.—Centrifugation has the effect of considerably augmenting the force of gravity. The constituents of the cytoplasm, and particularly all those which are termed deutoplasm (*i.e.*, the secondary or nutritive plasm or albuminous part of the yolk which provides food for the embryo) are arranged according to their density in parallel strata, which are often different in color. McClendon clearly proved this with the eggs of the sea-urchin and of the frog. It appears that this separation of substances having different densities in no way alters the germinal localizations of the egg. Conklin was able to modify by centrifugation the eggs of Molluscs the differently colored layers of the cytoplasm, but the first plane of segmentation and the bilateralness which is early manifested by a marked degree of asymmetry are not altered or modified in any manner. In proportion as the differentiation of the egg increases and as a new sort of germinal localization is elaborated (doubtless under the influence of fecundation) the centrifugation becomes more effective and the development more greatly disturbed.

Some authorities have even suggested that the profound modification produced in the first stages of development might be capable of modifying the sex of fertilized eggs, but Whitney has shown that this is not true.

When the centrifugal force ceases to act upon the eggs there is a reaction of the germ, which tends to resume a typical form. This regularization entails the bringing back to position of the substances which were displaced by the centrifugal action. Thus, when an experiment is made upon an egg in the stage of four blastomeres and when the equatorial partition is formed immediately after the experiment, the displaced substances are not able to redistribute themselves in the newly separated blastomeres and the germs consequently die. B. Konopacka proved this with frogs' eggs.

In these experiments there would also be a deviation of the first plane of segmentation; the female pro-nucleus being displaced by the centrifugal action the spermatozoid, whose trajectory decides the direction of the first plane, is obliged to change its path.

Certain interesting observations of Morgan show that the karyokinetic figures are displaced like solid bodies under the influence of the centrifugation and act upon those regions of the egg where various substances are accumulated, such as the pigment, the citellus (the yolk) or an oily material, without these modifications of the cytoplasm influencing the cellular division and the separation of the blastomeres.

X. INFLUENCE OF VARIOUS RADIATIONS UPON DEVELOPMENT

Ultra-violet Rays.—Stevens made use of the ultra-violet rays in the study of the development of the *Ascaris megalocephala.* One or more blastomeres are arrested in their development according to the stage of the development at the time of the exposure embryo is complete or abnormal. A prolonged exposure of the eggs to these radiations does not kill them immediately, but does definitely arrest their development; the mitoses are completed, and the blastomeres are able to change their position in the interior of the shell, but no further segmentation is produced. To sum the matter up the action of the ultra-violet rays does not modify the cellular divisions in their course but alters the following mitoses whose chromosomes are irregularly fragmented.

Fauré-Frémiet confirmed these observations; Guyénot has made a study of the eggs and larvæ of a fly (*Drosophila ampelophila*). Eggs which had been laid were exposed to ultra-violet rays and failed to develop. On the other hand, the only modification which appeared among the larvæ similarly exposed was a greater degree of mortality. When flies which were about to deposit their eggs were subjected to the ultra-violet rays they produced eggs which developed normally or proved abortive, according to whether they were laid immediately after the irradiation or several days later. There are still more remote results: Flies descended from eggs which had undergone irradiation in the body of the mother exhibited melanic forms and a partial or even total sterilization.

X-Rays.—It is in the cellular division, likewise, that the influence of X-rays is manifested as shown by Gaskell. The mitoses are retarded or even inhibited.

Under these conditions the development of the embryos is considerably retarded if not entirely arrested; but as there is nothing specific in the action of these rays the proportions of the various organs or tissues are not disturbed.

Radium.—The action of radium upon the development of embryos has been the subject of a considerably larger number of researches. The experiments of J. Tur with various germs both vertebrates and invertebrates are especially notable. He finds that the effects of radium are not immediate. There is a period during which the action is purely latent, and subsequent to this specific destructions of cells make their appearance, being limited to certain formations, principally to the embryonic nervous elements and to the first rudiments of the muscles. When the irradiation has been sufficiently early and effective, all trace of the embryo is destroyed: Germs minus an embryo or anidian germs. Certain eggs are more sensitive to the action of radium than others—thus duck eggs exhibit more complete alteration than hen's eggs, doubtless because of the slower development of their germ.

Hertwig has discovered in the eggs of amphibians the period of latency in the action of radium. As in the experiments of Tur it is the rudiments of nerves and muscles which are first altered. The sustaining tissues and the rudiments of the alimentary canal are much more resistant. The alteration of the cells was found to be concerned almost exclusively with the nucleus. Payne confirms these results, having observed under these conditions an irregular crumbling of the chromosomes. Packard, on the other hand, affirms that the alterations due to radium occur in the cytoplasm as well as in the nucleus. They seem to vary, moreover, according to the species. Under the same conditions Packard has obtained a cytoplasmolysis in the eggs of the *Nereis*, whereas in those of the *Arbacia* only the chromatine of the nucleus is affected apparently.

Veroni has found that in the action of radium upon the germ of the hen's egg there were produced not only phenomena of retrogression but also excitations of tissues causing an

increase in certain elements such as those of the mesodern. At the same time these cells lose their specific aspect, becoming non-differentiated and assuming the aspect of cancerous cells. After partial destructions have occurred, notably in the rudiments of the nervous system phenomena of regeneration have been observed. Furthermore, the action of radium enables us to make interesting observations with respect to the cellular differentiation of the embryo.

FIG. 2. GERM OF TOAD WHICH HAS MADE ITS SOJOURN FOR THREE DAYS IN THE PERITONEAL CAVITY OF AN ADULT. IRREGULAR SEGMENTATION (AFTER BELOGOLOVY)

XI. INFLUENCE OF CHEMICAL AGENTS UPON DEVELOPMENT

We shall not here consider experiments in artificial parthenogenesis by means of various substances, but rather examine certain experiments in which chemical products exert an effect upon the germ in the process of development. The choice of these substances is either purely empirical or occurs in accord with a preconceived theory.

Thus Coventry has studied the influence of acetic acid and hydrochloric acid and of soda upon the tadpoles of toads. Jenkins used chloride or sodium in various solutions to act upon the developing eggs of the frog. Reinke and also Stockard have observed modifications in the development of the tadpoles from the use of ether. By employing saline solutions Loeb has obtained a di-embryony in the sea urchin. All of these researches give the impression of having been conducted somewhat at hazard and their results have rather a curious value than a general application.

Far more interesting are the observations of Werber, who is of opinion that natural monstrosities result from the action of substances proceeding from a pathological metabolism of the parents, as, for example, from butyric acid or acetone. These substances have a very definite teratogenic (*i.e.*, producing monsters) action, which is manifested from any of those areas in which the embryonic cells exhibit the most active metabolism, as, for example, in the head. The result of this action is *blastolysis* which reveals itself in various monstrosities. Experiments in which chemical substances are made to act upon eggs or germs demand a previous study of the conditions according to which the substance is applied. The researches of Waelsch were deprived of all their value because he forgot this side of the question. He made use of the scarlet dye to influence developing hen's eggs. The normal development of the embryos of birds can be readily observed by making a large breach in the shell. I, myself, together with M. Ferret, have demonstrated that it is not the same when the lesion of the envelops of the egg is very reduced—*e.g.*, after being pricked by a needle. It is only just to add that our researches, which were published in the French language, bear the date of a period when German science was in ignorance of affairs beyond the Vosges.

Waelsch employed scarlet red dye dissolved in oil as a result of the observations of Fischer who, upon introducing this substance under the skin of the ear of a rabbit, obtained epithelial proliferations resembling a cancer (carcinoma) in aspect. It is likewise to the stimulating action of this product that Waelsch ascribes the monstrosities produced by him and which concerned the rudiments of the central nervous system exclusively. However, Ferret and myself obtained all the malformations described by Waelsch merely by pricking the egg without introducing any chemical agent. In fact one might think that the majority of the drawings in his work had been made with tracing paper from those in a treatise by Ferret, so close is their identity. It is our intention to discuss in another review the explanations given by Waelsch with respect to the mechanism of certain monstrosities. . . . But at present we will merely remark that in case scarlet red does exert an effect upon the germ of the hen's egg such action is superposed upon the influence exerted by simply pricking the inner membrane lining of the shell and the albumen of the egg. In a more recent work Waelsch describes epithelial proliferations obtained by introducing scarlet red under the skin of the larvæ of salamanders.

XII. TRANSPLANTATIONS OF EMBRYOS OR OF EMBRYONIC TISSUES

The principle governing these experiments is the inquiry into the cause of tumors in general and of teratoma (a tumor composed of a heterogeneous mixture of tissues sometimes found in new-born children), in particular. Embryologists have long been in the habit of making the experiment of grafting embryos into the adult tissues of individuals of the same species. The results obtained through such experiments are of the greatest variety and of unequal interest. Apparently the causes favorable to such translation must be sought in the differences of species. A graft of an embryo of one species almost never succeeds upon an individual of different species, even when the latter is proximate; furthermore, grafts of embryos of the same species will develop in the peritoneum. It appears to be true, also, that in the case of each animal there are different regions in which such transplantations find the optimum conditions. The nervous system of the adult appears to have no influence upon the development of the embryonic graft.

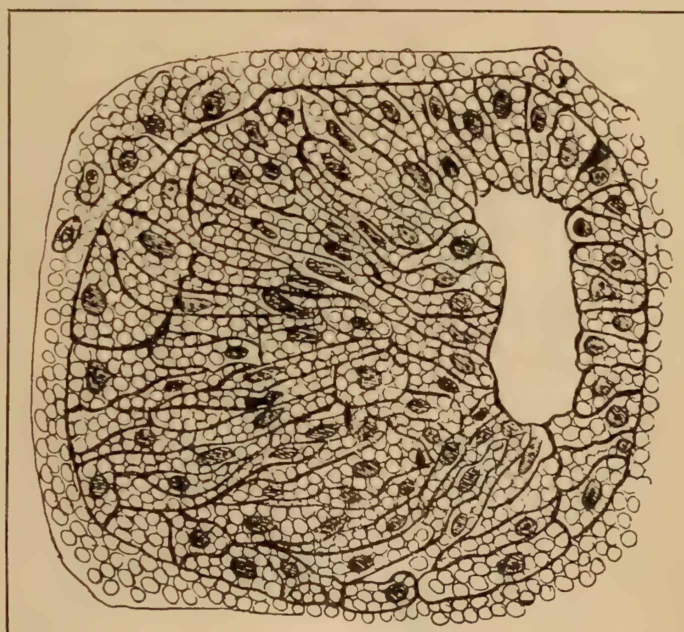


FIG. 3. RUDIMENTS OF AN ORGAN—PROBABLY OF AN OCULAR VESICLE— WITHIN A SYNCYTIAL MASS FOUND IN THE GERM OF A TOAD TWENTY-THREE DAYS AFTER TRANSPLANTATION. (AFTER BELOGOLOVY)

Grafting Eggs Into the Adult Peritoneum.—Among all recent researches that which we regard as offering the greatest interest to the readers of this review is that of G. Belogolovy. His experiments consists in the introduction into the peritoneal cavity of adult frogs and toads, eggs of the same animals in the process of development. The eggs of the frog are not killed in the organism of the toad, nor those of the latter in the body of the former. This certainly could not be the case among mammals, which are more differentiated from each other with respect to the chemical composition of the internal milieux.

Belogolovy deprives the eggs of their albuminous envelop and introduces them into the adult animal while they are still in the first stages of their evolution: morula, blastula, gastrula, neurula.

These germs thereupon become true parasites in a milieu which is very favorable to the life of their elements. As a result there is a simplification of their form and of their structure—a veritable functional adaptation to an easier kind of life. This investigator's observations were continued for several months with results extremely varied and interesting. His interpretations, however, appear open to frequent objections.

We will give here a brief résumé of the facts themselves (Figs. 2-5):

The typical development of the egg of the Anura, *i.e.*, tailless amphibian, which has become a parasite in the peritoneal cavity of the same adult animal is modified in a degree proportionate to the earliness of the stage at which the germ in question has been transplanted. This germ becomes dissociated into cellular masses or into isolated cells; the one and the other of these may behave in very different manners—they may on the one hand appear as tissues or as fragments of typical organs such as cartilage, glands, bones, portions of muscles, the dorsal cord, or cerebral vesicles; or they may, on the contrary, constitute formations which differ completely from normal tissues such as cysts, plasmods and cells of sarcomatous aspect.

The action exerted by the embryonic parasite upon its adult host is peculiarly interesting. The embryonic cells of sarcomatous aspect penetrate the tissues of the host, destroying the latter's organs and finally killing it in the course of a few months. The adult organs in contact with the embryonic parasite exhibit a growth and power of regeneration much more active than under normal conditions.

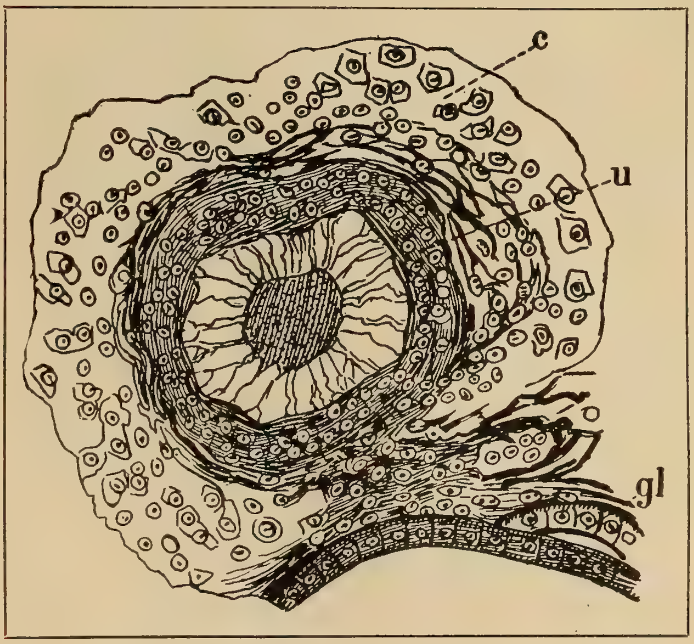


FIG. 4. EMBRYONIC FORMATION WITHIN THE GERM OF A FROG FIFTY DAYS AFTER TRANSPLANTATION

c = cartilage; *u* = urinary canalicula; *gl* = epidermic gland. (After Belogolovy)

It would be of interest to apply the ideas of Child referred to at the beginning of this review to the explanation of the dissociation of germs observed by Belogolovy. In the mind of the latter the concept of individuality is quite simple, namely, that the living organism is a portion of space limited by an ectoderm or outer skin.

FIG. 5. DETACHED CELLS OF SARCOMATOUS ASPECT IN THE GERM OF A FROG, TRANSPLANTED 83 DAYS PREVIOUSLY, WHICH HAS PENETRATED THE TISSUES OF THE ADULT HOST (AFTER BELOGOLOVY)

Inside of this ectoderm is a milieu very favorable to the life of cellular elements; outside of it there are conditions much less propitious to living matter.

In the experiments we have just cited the external milieu would be as favorable to life as the internal milieu; thus the ectoderm having lost its reason for existence perishes and ceases to limit the living creature which, therefore, becomes dissociated and abandons its individuality.

The interpretations by which this authority explains cystic or plasmodial formations, which are compared to many-celled organisms adapting themselves to the new conditions of life created by the state of parasitism, are likewise still open to discussion. None the less the facts observed are very curious and one of the most important and striking of these undoubtedly, is the direct transformation of embryonic elements into cells of cancerous nature.

AN EXPERIMENT ON REGULATION IN PLANTS

In an article in *The American Naturalist* for July-August, 1920, Professor E. Newton Harvey, of Princeton, offers an interesting discussion of Regulation in Plants in connection with an account of his own investigations in this field.

It is obvious to one who seriously contemplates the facts of regulation, says Professor Harvey, that the influence of one part over another in the organism must be either similar to nerve influence and depend on living protoplasmic continuity between the parts, or due to the actual transport of material from one region to another.

Harvey considers the second of these possibilities—transport of material. Two views are prevalent regarding the nature of this transport. (1) A growing stem may be supposed to form material which inhibits shoot formation and a growing root to form material which inhibits root formation. These special inhibition substances pass downward and upward in the stem respectively. Polarity is a direct consequence of the formation

of these substances and their direction of flow. (2) In a whole plant, because of a certain morphological structure, the nutrient channels are such as to carry food material to growing regions. A plant grows at both ends and so long as these are intact and growing, food flows toward them. If removed, food flows to other points and starts the growth of dormant short buds or root primordia. Once a stem or root has started growing Loeb's experiments show very clearly that the mass of growth formed is proportional to the mass of materials available.

Harvey considers that light is thrown on this problem by experiments of his own, designed to divide a plant into two parts physiologically but not morphologically. A jet of steam was directed against the stem of a young bean plant between cotyledons and first pair of leaves in order to kill the tissue throughout the stem in this region. In some plants the leaves and growing tip above this region wilt and die, but in many cases not only does no wilting occur but the tip continues to grow and *as rapidly or more rapidly* than control plants under the same conditions which are unsteamed. Nevertheless the *cotyledonary buds below the steamed region begin to grow and roots start to appear just above the steamed region.* If the air were sufficiently moist or the region surrounded by water there is no reason why these incipient roots should not grow out into a typical root system.

Harvey presents some of his results in a table which shows the data regarding the growth of "control" and steamed plants whose tops were not killed by the steaming. The average growth for the controls is 40.5 mm., and for the steamed plants, 59 mm. It is evident from the table also that the terminal bud has grown in the 24 hours immediately after steaming so that it cannot be said that the steaming causes even a temporary cessation of growth of the tip.

In discussing his results, it is certainly true, Harvey says, that sap must pass up the stem of these steamed plants, otherwise the tops would remain turgid and growth occur. Root inhibiting substances, if formed, must have passed upward along with the sap. Nevertheless we find roots developing above the steamed region despite the fact that the plant has a normal living root system below. The evidence is, therefore, conclusively against the existence of definite root inhibitive substances. If sap can pass upward in a steamed area we might expect that it could pass downward also. If inhibitive substances are formed by a growing stem these materials should reach the cotyledonary buds below. Nevertheless these buds develop. Since we cannot necessarily argue that because material can pass up a stem it must also pass down, the evidence points against the existence of shoot inhibitive substances, but is not unequivocal.

In a plant which has been steamed the nutrient channels are the same as in a normal plant. The apical bud is growing and attracting material to it so that we cannot say this food material is now available for the cotyledonary buds as we might say, had the growing tip been actually cut off or prevented from actively growing by a hydrogen atmosphere. The evidence is conclusively against the view that growing points prevent the growth of dormant buds by attracting and utilizing the nutrient material.

In conclusion Harvey says: "It would seem that the inhibitive influence must be dependent on living functioning protoplasmic connections. How are we to conceive of an influence of this sort without invoking a vitalistic explanation? I believe the explanation lies in the direction developed at length with the aid of metal models by Lillie.* Growing points are of a different electrical potential as compared with other points and the currents so generated passing through dormant buds in the proper direction, prevent their growth. The potentials are phase boundary or membrane potentials, possibly dependent on selective ionic permeability or solubility of two phases (cell and medium) to ions, and consequently dependent on normal permeability conditions throughout the plant. Interruption of living protoplasmic connections, then, means merely the interruption in continuity of semipermeable membranes in longitudinal axes of the plant (vascular bundles?) While we may be sure that the steamed portion of a plant will conduct an electrical current, since its normal semipermeable membranes have been destroyed there is no means of obtaining a return circuit. The plant is divided into two electrical systems instead of one and behaves practically as two distinct plants. As Lillie has suggested the effect of gravity on the inhibitive influence of growing stems, pointed out by Loeb, may be explained by movement of sap downward and passage of a greater current through this region because of increased electrical conductivity there. Biological polarity thus becomes electrical polarity and a given process at one region or pole is automatically accompanied by the reverse process at the opposite region or pole."

*Lillie, R. S. *Biol. Bull.* XXXIII, 135, 1917.

THE COMPARATIVE VALUE OF THE LABOR OF WORKMEN

The brilliant French physiologist, Jules Amar, with whose important researches, especially regarding muscular activity, men of science have long been familiar, has recently been making a special study of the varying yield of workmen. Some years ago M. Amar made the important discovery that the consumption of oxygen is directly proportional to the muscular activity of an animal. This is significant from two points of view: It is of interest, on the one hand, to know the amount of oxygen absorbed by the body during any piece of work, whether useful work or some form of sport, and, on the other hand, it enables a physician or trainer to perceive in the graph recording the respiration, the degree of regularity or the disturbance of the latter.

Results of M. Amar's researches as given August 9th, 1920, to the French Academy of Sciences, can be briefly stated as follows:

1. When a workman performs a professional operation without overdoing himself, without excessive effort or accidental strain, his respiration is quite regular, both as regards the ventilation of the lungs and with respect to the appearance of the respiratory curves recorded.

2. The same operation performed by a number of workmen reveals differences in the amount of oxygen consumed which depend upon various factors, such as the degree of manual skill, the general good health and condition of the body, the facilities provided by the workshop, etc. Obviously factors such as these will vary according to the individual and to circumstances in general.

A very interesting point in this connection is, that the economy of respiration among apprentices increases in direct ratio with the amount of skill acquired.

3. Any awkwardness or clumsiness in the performance of the allotted task, as likewise any sort of malingering, whether the pretence of exerting extra force or as a simulation of weakness, is betrayed by disturbance of the air supply ventilation and by irregularities in the graphic record. These are so marked that it is impossible to mistake their source and thus a very easy method is at hand for the scientific foreman to check up soldiering" on the job.

4. Observations made upon athletes show that as a general thing they take a longer inspiration than usual and this encroaches upon the expiration. This fact proves that the organism makes a provision for itself at each respiration in excess of actual needs, thus storing up reserves for future demands.

This mechanism, which indeed certain athletes have practised intentionally, appears to be another example of those means of defence in which animal economy is so rich.

The general conclusion to be drawn from these experiments is that respiratory education is of the utmost importance both with respect to daily labor and to athletic sport, since it furnishes a means of providing the required oxygen for hematosis, *i.e.*, the arterialization of the blood in the lungs and for the vital changes which occur in the cell.

GROUP OF PATIENTS WAITING TO SEE THE DOCTOR IN THE CLINIC FOR ANIMALS AT BERLIN

A Clinic for Animals

Prescribing for and Operating upon Pets and Domestic Animals

WHILE in most cases wild animals appear to be practically free from disease since few of them live sufficiently long to experience the degenerative troubles of senescence, the animals which man has domesticated either as pets or for utilitarian purposes, are prey to almost as many ills of the flesh as he is himself. For this reason all of our agricultural colleges contain a department of veterinary medicine and surgery for the study of the diseases and injuries to which such animals are subject. Here and there, too, in our larger cities, are found hospitals for dogs and cats or for pet birds. But so far as we know Germany is the first country to establish a regular clinic, where animals of all sorts and suffering from the most various injuries and maladies can be taken for diagnosis of their ailment and advice as to the best method of curing them. As the accompanying pictures indicate the popularity of this institution is by no means confined to the humbler folk who patronize human clinics because of poverty. Here we see sitting side by side in the waiting room men and women of rank and fashion holding their suffering pets tenderly in their arms and bareheaded peasant women waiting to consult the wisdom of the doctor about the infirmities of their pigs and chickens, their horses and their kine.

Here we may see a white-coated surgeon and his assistant gently placing a dark cap over the head of a dog, whose eyes have just been operated upon, while yonder some other suffering animal is being carefully bandaged. The owners of animals which can be successfully treated at their own homes receive careful instructions and take their property away with them. For those creatures whose condition is more serious and who require, therefore, expert attention and trained care, there is a hospital connected with the clinic, where they may stay until they are cured or well enough to complete their recovery at home.

In the third contingency that the animal's condition is found to be hopeless, the owner is summoned and gently advised that it is the part both of wisdom and of kindness to put the poor creature out of its misery, as the saying goes, rather than allow it to undergo weeks or months of uncomprehended agony or the discomforts of debility and decline. In such instances many are the pathetic scenes of farewell between a doting owner and a treasured friend and companion as of some beloved dog or favorite cat.

The advantages of such a clinic, particularly where accessible to a rural population, are strikingly evident. By prompt consultation of their experts a farmer may save not only a valuable individual animal, but may be enabled to prevent the spread of disease among his own herds and throughout the agricultural community. Again, just as the young physician derives invaluable training by the study of the thousand and one cases that come under his observation in a public clinic for men, women, and children, so the veterinary surgeon may

TWO WELL CARED FOR SUFFERERS

BANDAGING A BADLY MANGLED PATIENT

OPERATING ON A BAD CASE OF CANKER

secure a most useful working knowledge of the subjects of his future practice.

Such an institution may render important service to the community at large and, indeed, to the country in general. by the opportunities it affords for the discovery of incipient infections and the stamping of them out before they have a chance to sweep the country, destroying millions of dollars worth of property and even endangering, to some extent, the health of the populace, as in the cases of bovine tuberculosis. anthrax, glanders, foot and mouth disease, etc.

Finally, the personal observation of the good done by modern methods of the study and cure of disease would go far to check the ignorant superstition which still prevails among certain classes of people, to the effect that vivisection is merely senseless and useless practice of needless torture upon our humble and dependent friends. On the contrary, animals themselves have gained as much in relief from suffering and disease as have human beings through the information to whose door vivisection is the only key.

THE POWER OF HOLDING THE BREATH AS A TEST FOR LUNG CAPACITY

ONE of the valuable bits of information brought out by the tests for aviators made during the war, was the practical usefulness of the measurement of the time the breath could be held after taking a deep inspiration, for deciding the fitness of the subject to become an air pilot. This voluntary apnœa. as it is termed by physiologists, has been more recently studied by the French physician, Dr. L. Binet and Dr. Bourgeois, and the facts observed by them are worth the attention of schoolmasters, as well as of authorities upon hygiene.

When an adult person in normal health is asked to take a profound inspiration and then to hold his breath as long as possible, it is usually found that the average time during which he is capable of suspending respiration, varies from 40 to 50 seconds. When lying down this time can be extended, while when muscular exercise has been taken immediately before the time is considerably shortened. These studies of normal persons have now been extended to certain classes of invalids and we quote from some of the data observed from the *Presse Médicale* (Paris) of June 12, 1920, as abstracted in the *Revue Scientifique* (Paris), for October 9, 1920.

Patients suffering from chronic bronchitis or pulmonary emphysema are able to hold their breath, upon an average, not more than 21 seconds, while in tubercular patients this time is reduced to 14 seconds. Cardiac patients having a "compensated" lesion can hold the breath for about 34 seconds, while those whose affection is hypo-systolic in nature can do so for only 19 seconds.

The physicians mentioned stated it to be a general law that whenever there are disturbances of the respiration, due either to lung trouble or heart trouble, the period during which the breath can be held voluntarily is decreased in proportion to the gravity of the trouble. However, this decrease bears no relation to any diminution of the capacity of the lungs and some persons who are capable of inhaling a very large volume of air are, nevertheless, incapable of holding the breath for the normal period of time.

TESTING THE HEART AND LUNGS OF A DELICATE TOY SPANIEL

PUTTING ON A PROTECTIVE CAP AFTER AN OPERATION ON THE EYE

The Detection of Imitation Furs

How the Microscope Enables Us to Distinguish Real Furs from Spurious

By Leon Augustus Hausman, Ph.D.

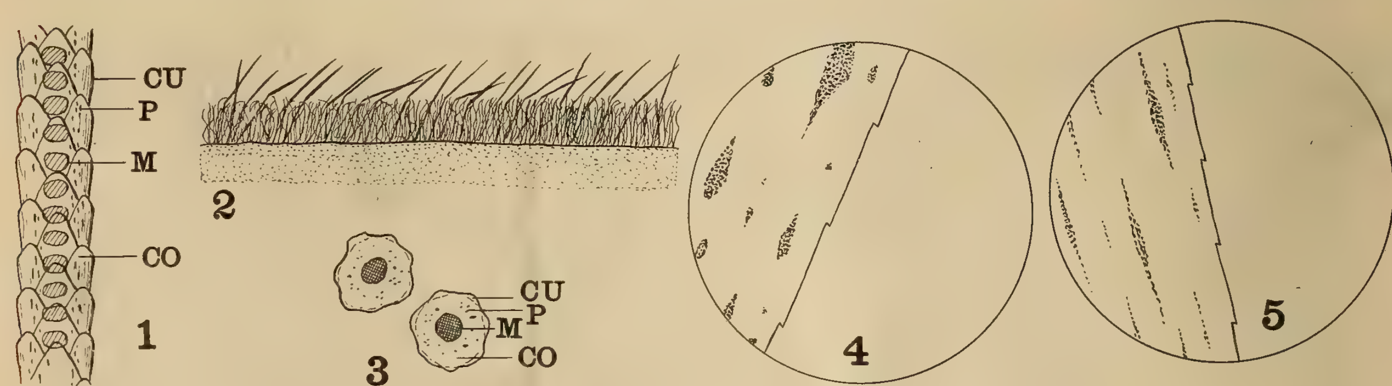
THE increase in the demand for furs during the past several years has been phenomenal. Not only, as formerly, are furs being made up into garments designed primarily for warmth during the winter, such as coats, scarfs, muffs, caps, and the like, but in addition are in ever-growing demand as articles of ornamentation at all seasons of the year. Furthermore the hair of many of the furred animals is employed in large quantities each year in the making of felts and similar fabrics. As a natural result, in the growth of the demand for furs, increasingly greater numbers of fur-bearing animals are, year after year, being killed, and at such a rate as to overbalance the natural tendency toward increase. Legislation designed to protect various species of valuable fur-bearers has been put into operation, but apparently the reduction still goes on. Certain mammals, once abundant, stand, today, in alarming proximity to extinction. And hence it is that many of the superior furs are becoming rarer and consequently progressively more expensive.

This growth in the rarity of certain furs has given rise to the ubiquitous attempts to furnish purchasers with imitations. the attempts have been legion, and considerable success has attended upon many of them. Sealskin, ermine, fox, bear, beaver, sable, chinchilla, otter, and others can be purchased at suspiciously reasonable prices, and seem to be suspiciously abundant. This is because it is now possible so to clip, dye, pull, and otherwise alter furs of certain types, that their original appearance is entirely lost, and that they may be sold under names not their own. Inferior furs, remodeled, may be sold under the names of furs much superior in wearing quality or in warmth, as for example when remodeled rabbit is sold for ermine or remodeled muskrat (perhaps the very one that you watched in an unremodeled state splashing about in your trout stream on your last fishing trip) is sold to you for your coat collar as seal of some sort or other at ten times its legitimate value, warmth and durability considered! The pelts of animals from warmer latitudes such as the opossum, marmot (woodchuck), raccoon, Manchurian dog, and certain species of monkeys are worked up and altered by skilful dressers into products very much different from their originals. The names which are given to such remodeled furs are usually the names of animals of colder latitude, which possess furs of quality superior to those of warmer zones in respect to suppleness and durability of skin, durability of the hair, denseness and softness of the under, or fur-hair, and fullness and length of the over or protective hair. Not only is there this natural difference between furs from animals of warm and cold latitudes, but another, an artificial difference exists as well. This is the difference produced by the dyeing and processing to which the warm latitude furs are subjected during the alteration process which often renders the individual hairs brittle and the whole fur less durable, in general, than it would have been in an unremodeled state. A comparison of the relative durability of furs with respect to their wearing qualities is very illuminating.

RELATIVE DURABILITY TABLE

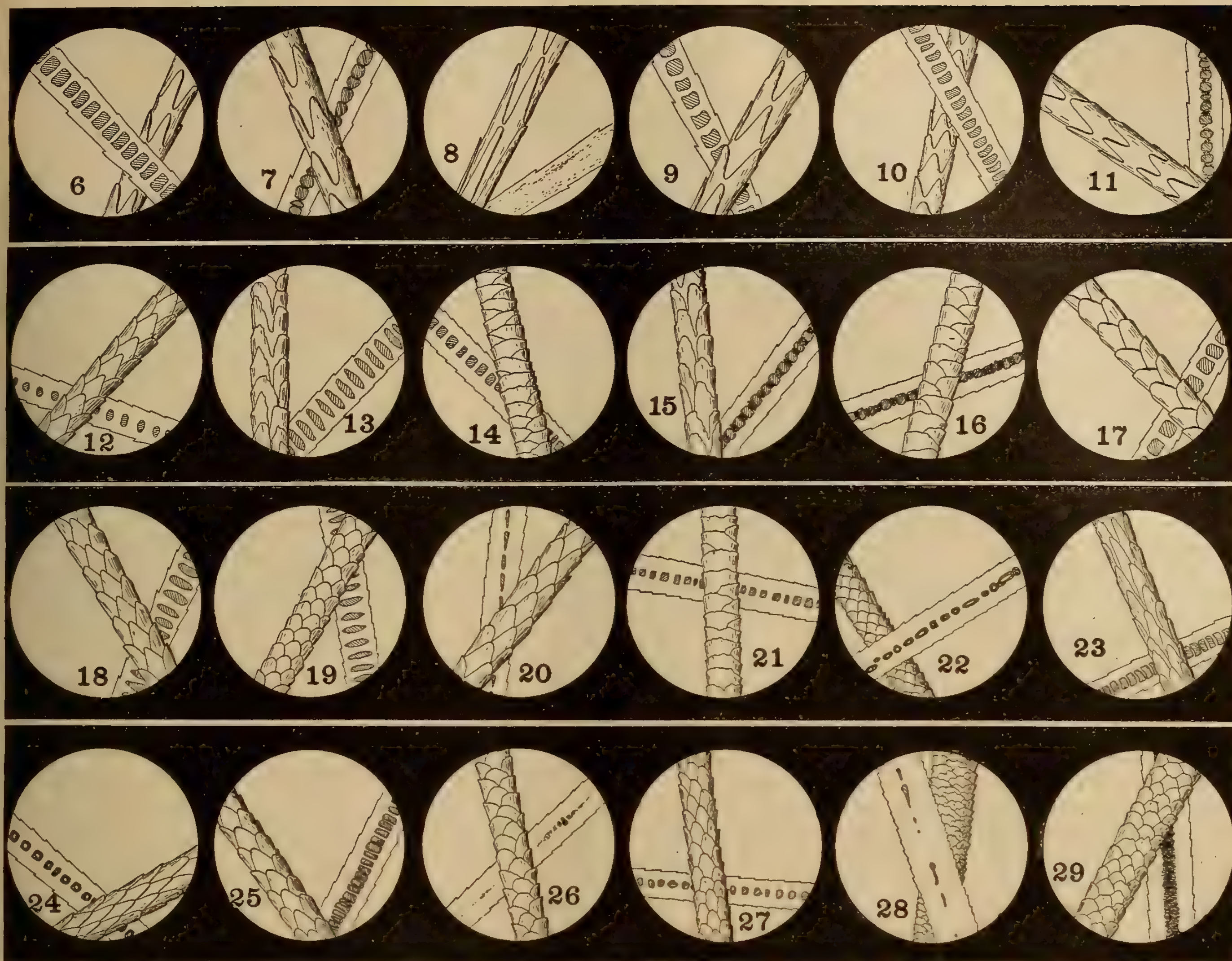
Vernacular, or common name of species	Relative durability Sea otter as standard, 100
Beaver	90
Bear, black or brown	94
Chinchilla	15
Ermine	25
Fox, natural	40
Fox, dyed	*20-25*
Goat	15
Hare	5
Kolinsky	25
Leopard	75
Lynx	25
Marten (Skunk)	70
Mink, natural	70
Mink, dyed	*35*
Mole	7
Muskrat	45
Nutria (Coypu rat), plucked	*25*
Otter, sea	100
Otter, inland	100
Opossum	37
Rabbit	5
Raccoon, natural	65
Raccoon, dyed	*50*
Sable	60
Seal, hair	80
Seal, fur	80
Squirrel, gray	20-25
Wolf	50
Wolverene	100

The above table by Peterson gives the relative durabilities of the furs when used with the fur outside, and not for linings. For comparison, the fur of the sea otter (*Latax lutris*), is assigned a standard of 100. In comparison with this table



FIGS. 1-5. THE STRUCTURE OF TYPICAL MAMMAL HAIR

Fig. 1. Typical mammal hair, showing the position and relationships of its structural elements. CU., cuticle, in the form of separate, imbricate scales; P., pigment granules; M., medulla, in the form of separate cells or chambers; CO., cortex. Fig. 2. Diagrammatic representation of the relationship of the fur to the protective hair, as it occurs in mammals. From the Duckbill, or Platypus (*Ornithorhynchus anatinus*). Fig. 3. Transverse sections through the fur hair of the Platypus to show the form of the medulla. Lettering as in Fig. 1. Figs. 4 and 5 show respectively, portions, very highly magnified, of the hair from the domestic cat, and brunette American to illustrate the way in which the pigment granule patterns in the cortex differ. Fig. 4 is typical of most of the fair-haired monkeys also. With higher magnifications differences also in the shape of the individual pigment granules themselves become appreciable.



FIGS. 6 TO 29. MICROSCOPIC APPEARANCE OF HAIRS OF SOME OF THE COMMON FUR-BEARING ANIMALS

consider now the one following, giving on the left the true names of certain furs and on the right the names under which these furs are often sold.

TABLE OF USUAL MISNOMERS IN FURS

The True Species	Altered and Sold as
American sable	Russian sable
Fitch, dyed	Sable
Goat, dyed	Bear, of various kinds
Hare, dyed	Sable or fox, of various kinds
Kid	Lamb
Woodchuck (Marmot), dyed	Mink, sable, marten (skunk) a very common misnomer
Mink, dyed	Sable
Muskrat, dyed	Mink, sable, very common
Muskrat, pulled and dyed	Seal, electric seal, etc., Red River Seal, Hudson Bay seal
Nutria (Copyu rat), pulled and dyed	Same as muskrat pulled and dyed
Nutria (Coypu rat), pulled, natural	Beaver, otter
Opossum, sheared and dyed	Beaver
Otter, pulled and dyed	Seal, of various kinds
Rabbit, dyed	Sable
Rabbit, sheared and dyed	Seal, electric seal, Hudson Bay seal, Red River seal, musquash (muskrat)
Rabbit, white	Ermine
Rabbit, white, dyed	Chinchilla
Kangaroo (wallaby), various species, dyed	Skunk (marten)
Hare, white	Fox
Goat, dyed	Leopard

The need of some certain criterion by which furs can be indubitably identified, as to species, is clear. In some recent publications dealing with the microscopic structure of the hair shaft from the zoölogical point of view, the author has pointed out that certain structural elements in the structure of the mammal hair are characteristic of species, and are of value in determining the species from which the hair was derived, Mammal hair, as a rule, consists of two very different sorts: (1) a short, rather dense, fine growth, called the under-hair, or fur-hair; and (2) a longer, coarser, stouter over-hair, or protective hair. Most species of mammals possess both types of hair (Fig. 2).

In both of these types of hair, the shaft is composed of four structural elements, distinguishable, after proper treatment, under the microscope, elements which no amount of dyeing or other processing, short of actual destruction of the hair as an article of value, can destroy. It is these minute and ultimate units of the structure of the hair which aid the microscopist in determining the species of mammal from which the hair was obtained. Fig. 1 shows a typical mammal hair shaft with the four structural elements indicated. These are: medulla, cortex, cuticle, and pigment granules.

The medula, or "pith" of the hair exists in various different forms, the chief major types, from which the variations seem to be derived, being: (1) the continuous (Figs. 29, 15 and 16), the fragmental (Figs. 26 and 28), and the discontinuous, or ball-like (remaining figures). This element is sometimes absent, or present only as minute vestiges of tissue scattered along the whole length of the shaft. Where but meager traces, like this exist in the hair a search near the mouth of the follicle in the skin—from which the hair grows—will usually reveal a portion of a fully formed medulla. The cortex element sur-

rounds the medulla, and usually forms the greater part of the hair. It is composed of many elongate, fusiform cells, coalesced together into an almost homogeneous, and usually hyaline mass. The component cells of the cortex can be dissociated and made to float about singly on the microscopic slide, and thus their forms determined. The cuticle, or outermost layer of the hair shaft, is made up of thin, transparent, scales, which overlap, like the shingles on a roof or scales on a fish. Of these scales, two main types are recognizable: (1) the imbricate discontinuous scales (Fig. 12), and the imbricate coronal scales (Fig. 11). The latter have been so named from the resemblance of each single scale to a crown or coronet. A glance at the figures will show that these two types of scales are subject to all sorts of intricate variations. The color of the hair is primarily due to a fourth element, the pigment granules. Although the pigment of the hair may sometimes exist as a diffuse color, distributed uniformly throughout the cortex element of the hair shaft, yet in the majority of species the pigment exists in the form of separate granules, scattered about among and within the fused cells of the cortex. These are scattered about, not apparently in "hit or miss" fashion, but are arranged in patterns of definite configuration in each species. Not only this, but the granules are characteristic also, in the color value and depth, shape, and size. They form, it is believed, a criterion, which, with further study, may prove to be of the greatest aid in specific determination. (Figs. 4 and 5). It is these microscopic elements in the structure of the hair whose forms, measurements in micra (1 micron equals approximately 1/25400 of an inch), and relationships constitute the series of determinative criteria to which reference has been made. No matter what may be done to the fur as a whole, short of actual destruction, these structures remain to indicate the origin of the pelt.

By glancing over the figures from 6 to 29 it will be evident that a series of known hairs in a collection can be arranged for microscopic examination and classified on the basis of the likenesses between various elements of structure. These can be filed away for comparison with unknown specimens.

The ordinary methods of preparation of hairs for microscopical examination have been discussed in the author's earlier papers and can be made readily after a little practice. Examination may be made, and is often necessary, of both the under- or fur-hair, and the protective, or over-hair. It sometimes proves helpful, also to prepare transverse, or cross-sections of the hair shafts. Several sections of this sort are shown in Fig. 3.

Figs. 6 to 29 show the microscopic appearance of hairs from some of the common fur-bearing animals. In each figure two hair shafts are shown, one treated to show the cuticular scales, the other to show the medulla. In identifying hairs the same portions of the hair shafts used for comparison must be taken. Since the character of the hair shaft elements differ in different portions of the shaft, several comparisons may thus be had as checks upon one another. The number of comparisons which may be had, thus insuring greater certainty in the value of the identification, will be appreciated when it is recalled that there are offered always two, and often four well-defined characters for comparison, and these in two different types of hair (over- and under-hair). Furthermore these characters may be compared in three different regions of the hair shaft, *i.e.*, the base of the hair (just above the mouth of the follicle), the middle portion of the shaft, and the region near the tip. Figures 6 to 29 were made from the middle portion of the hair shaft.

In taking measurements of hair shafts with the microscope great care must be exercised, and the average of a great number of measurements taken to guard against error. Size of the hair shaft itself, and size also of its various components, forms one of the valuable aids in determination.

It is reported that the remodeling and misnaming of furs reached such a pitch in England, that several years ago the London Chamber of Commerce forbade the further employment of misleading terms, and pointed out that offenders laid themselves open to prosecution under the ruling of the Merchandise Marks Act of 1887. Such legislation might have a salutary effect in countries other than England. Where scientifically accurate methods of determination of the specific status of furs can be made available it would seem that the standardization of furs might be, with advantage, brought about.

SILK FROM THE SLAUGHTER HOUSE

EVEN before the war German scientists were seriously investigating methods of extending the sources for obtaining raw materials from which to make artificial silk. Naturally enough the subject has recently engaged fresh attention and the remarkable statement is made in *La Nature* (Paris), May 22, 1920, that such a silk can be extracted from the flesh, *i.e.*, the muscles of animals—from that of horses and cattle especially. The raw material consists of the flesh of horses which have been killed because of accident and of that of cattle condemned by the Bureau of Health. Since this flesh is, naturally, very cheap the raw material is obtained at low cost.

The flesh is first macerated in a liquid designed to dissociate the muscular fibers by dissolving the substance which holds them together. These fibers have the form of short, limp filaments; they are next allowed to remain for some time in a second liquid whose action is analogous to that of tannin, giving the material greater tensile strength and imparting to it a silky character. The final product of this treatment consists of fibers having an average length of 5 cm.; these are somewhat harsh to the touch and in a measure resemble wild silk.

The non-fibrous part of the flesh which has not been dissolved is sold to manufacturers of glue. The principal industrial property of these fibers resides in the readiness with which, like silk, they can be rubberized and vulcanized. When placed in a bath of caoutchouc for two hours under a pressure of four atmospheres they become waterproofed just as silk does under the same conditions.

While the liquids employed in the treatment have been kept a secret by the inventor, he states that they are not at all costly and he estimates that a portion of the cost will be defrayed by the sale of the flesh which remains after the dissolving of the muscular fibers. The question of how to spin this artificial silk has also been studied and it seems the process of spinning used for carded wood is that which best suits this animal fiber.

A TEXTILE FIBER FROM THE HIBISCUS

THE mallow known to botanists as the *Hibiscus Cannabinus* is a handsome plant found growing over wide areas in the valley of the Niger River. It is called by the native the *Da* or *Da-dain*. It is not generally known that this ornamental plant produces an excellent fiber somewhat of the nature of jute. Indeed, it is sometimes called in India Madras jute. It has long been used by the inhabitants of the valley of the Niger for making the ropes with which they bind together their pirogues, as well as for fishing lines and harness for animals. Since the war, however, its uses have been extended and its production increased. While its filaments are rather short they are long enough to be manufactured like jute. Their color varies from gray to rusty white.

The seed yields a drying oil of a clear yellow color and the cake which is a by-product employed as cattle fodder. The plant requires a good deal of water for its proper development and is, therefore, sown at the beginning of the rainy season, so that it may attain full development before the dry season sets in.

In 1914 and 1915 in the ground belonging to the agronomic station at Koulikoro, upon earth subject to intermittent inundation, 6 tons of the cut and dried stalks, freed from seed pods, were obtained per hectare. These yielded 21.8 per cent of fiber.

PILE OF FRESHLY CUT RUBBER THROWN ON THE STREETS OF MANAOS FOR LACK OF OTHER SPACE, WAITING SEPARATION AND PACKING

Due to this practice the streets are very often filled with a bad odor

Brazil's White Gold*

Primitive Methods, Still in Vogue, of Collecting the Milk of the Rubber Tree

By William La Varre

GOLD in the Klondike and diamonds at Kimberly are strikes of fortune that will be immortal, but gems and minerals do not compose all of Nature's treasure. I wonder if there has ever been a period in which romance was so interwoven with overnight wealth, gaiety, and extravagance as it was during the rubber boom in Brazil. It had its beginning back in 1770 when Priestly discovered that Brazilian rubber, which the aborigines knew considerable about in the early days of exploration, was an excellent thing with which to erase pencil marks. After Macintosh had found a method of waterproofing garments with the substance, and Charles Goodyear had hit upon a method of combining rubber and sulphur, thereby hardening it, the gummy produce entered more and more into common use. The people of Brazil realized that this new industry of the commercial world relied directly on the white latex which flowed in millions of native trees. They found themselves in control of a great enterprise which required no extensive machinery, costly experiments, or risks; simply the bleeding of the wild trees and the hardening of the collected juice so that it could be shipped to the clamoring markets of the world where it would bring fancy prices.

Of all Brazilian towns Manaos, over 900 miles up the Amazon, and accessible by ocean-going vessels of 7,000 tons, felt the pulse beats of the new industry more keenly because it was in the center of things—the frontier gateway—through which the produce must pass to the outside world. She sprang up suddenly from a little sleepy village, where every one dreamed of better days but had done nothing toward attaining them, to a town of many thousands—a metropolis in which there was a seething mass of cosmopolitan life that came from everywhere and went to and from the interior, bringing several hundred thousand kilos of dirty looking balls of borracha weekly, the sale of which at 17 and 18 milreis a kilo would make the owners wealthy men. A milrei, or a thousand reis, was worth about 25 cents in American currency, which fixed the price of raw rubber at about $2 per pound in Manaos during the years of its highest value. Some of these men who made fortunes saved all they could get, and after accumulating quite a sum left the country; others spent their earnings in planting seringals. But a good part of the people squandered their earning from each voyage on the night of their arrival after the manner of the reckless of all conquests.

In Brazil rubber is known as borracha, and the people like, when lapsing into fond musings, to call it "o ouro branco"—the white gold. During 1906-7 it was worth 18 milreis per kilo. The milk was taken from wild trees by natives, especially along the Amazon, Madeira, and Negro Rivers and their tributaries, smoked into large balls weighing from 40 to 200 pounds, and sold to traders, who forwarded them to Manaos.

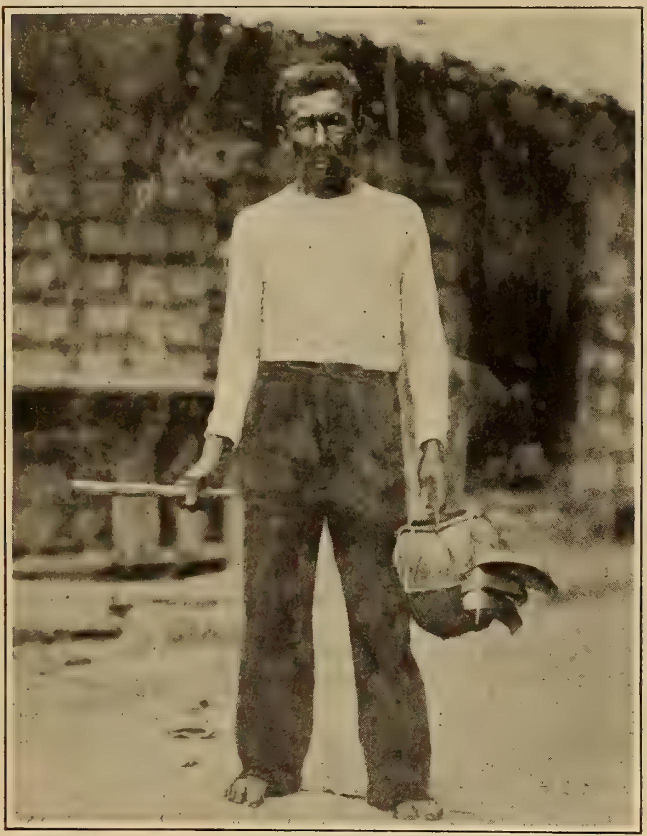
As in other sudden booms of wealth and fortunes, there came a slump in Brazilian rubber. One of the troubles was that people wanted to work for themselves, and would not work for others, or even band together into corporations of their own. Each native in the interior wanted to go out into the forest, find his own wild trees, bleed them, and smoke the rubber for himself. They preferred to work independently in this manner, laboring when they pleased, and how they pleased, even if they made only $1 a day.

The story of what happened to the goose that laid the golden egg is an old one, but fable makers of ancient days were wise old people. History repeats itself. Some of the natives decided that they might just as well cut the rubber trees down and take all the milk at once instead of drawing a gourd full a day for thirty seasons. So for several years, especially along the lower Amazon, they hacked away until, after several hundred thousand trees had been ruined, they realized that Nature cannot be hurried, however much in haste human nature may be. It was necessary to go easily and

* Abstracted from *The Pan American Union,* November, 1920, pp. 462-476.

slowly—a few well-placed and shallow cuts penetrating the bark only, will ooze the liquid gold for nearly half a century.

The labor question was the thing that turned the minds of certain promoters to new fields, with thoughts that perhaps there might be a possibility of transplanting those rubber trees to another country where labor would be very plentiful and cheap. The Brazilians took this idea with good-natured tolerance. "Well," they said, "it would not hurt to try, but Brazil is Brazil, and the trees that thrive in Brazil are not likely to live anywhere else." The British gathered a few shoots and carefully carried them into the East where they knew labor was to be had. Transplanted in Ceylon, India and other colonies, they seemed to thrive well, and more young trees were brought over and other plantations commenced. Then began the slumping of Brazilian rubber. It was discovered how cheaply rubber could be produced. Large companies became interested, and it was not many years before they were receiving nearly all of their raw material from west of the Pacific and from plantations of their own. The amazed Brazilians saw their rubber fall in value from 18 milreis to 4 milreis per kilo, and they began to mood and dream again. Some few started cultivating rubber in Brazil, but as yet it is small business in comparison with the Eastern holdings where labor can be had in abundance. Today Brazil no longer controls the rubber industry.



JOAQUIN, A TYPICAL RUBBER GATHERER
Note the small hatchet for gashing trees and the gourd bucket with the attached leaf cups

In 1919 I found myself nearly a thousand miles up the Rio Negro, in the midst of many poor natives who are managing to make a meager existence from smoking the few gallons of milk they are able to collect each day during the few months that the wild trees will profitably bleed their latex.

It was at Cucuhy, frontier outpost of the Brazilian Government on the Rio Negro, that I had the best opportunity of observing the natives—the "little men" in the rubber industry—at their work. The place was very lonely, and to pass the time I used to spend whole days in the forest with the collectors. Of them all I remember more especially old Joaquin da Silva, a little wrinkled Caboklo, or half-breed. He lived with his wife, a son of about 30 years, and two young children, in a little thatched hut beside a twisting egarupe that flowed into the Negro from the east.

One evening old Joaquin was squatting down in one of the thatched huts where I lived on the banks of the Rio Negro. He was telling me of the hard time he was having to collect enough rubber to provide himself with the necessary requisites of life as he knew it.

"It is very bad, senhor," he said, "my trees do not give as much milk as they used to, and I have to walk farther and farther to get 4 quarts of white *leite*. I am growing old, and soon I will not be able to walk so far; what shall I do then?"

I did not answer him, because I did not know what to say. After a while of thoughtful silence I said: "Joaquin, will you take me with you into the forest so that I may watch you get the milk?"

"Certainly, senhor," he replied in his soft, lisping tongue. "If it does not rain, I will come for you at 6 of the morning—if it rains as it did this morning, there will be no use in going, for the milk will be ruined again."

At 6 the next morning I was dressed and waiting for Joaquin. With customary readiness he arrived at 7 and we started off together up the meandering egarupe in his little dug-out canoe. It was an ancient craft, barely large enough for two, and there was but an inch of freeboard when we had taken our places. Joaquin sat in the bow, with his blunt feet extended out over the water ahead of us, and paddled with short, quick strokes against the current. When shallow places were reached he stood up and poled, causing me to hold my breath for fear the next motion would cause the canoe to overturn.

At a bend in the stream, where granitic rocks outcropped, we paused while Joaquin got out and fetched a small gourd bucket, leaf cups, narrow-bladed hatchet, and a bow and several fish arrows from his home, which was hidden from view behind the light green leaves of banana palms.

We continued up the ever twisting and narrowing creek for an hour to another clearing in which there was a tumbled-down shack. Here we left the canoe and, picking up our equipment, we took to a small trail that led into the forest. Joaquin picked up a handful of soft clay which he placed in the gourd bucket, and gave me a bundle of long, slender, and very light rods of pith to carry, which had been lying over a fallen log to dry in the sun. We soon had left the warmth of the sunshine behind and were journeying through the dark dampness of the jungle.

Presently Joaquin stopped at the base of a tree around which a space had been cleared of undergrowth. The tree was perhaps a foot in diameter and rose straight upward for 20 feet before it branched. The bark was somewhat furrowed and mottled with green, brown and gray tones. The leaves grew in clusters somewhat like our hickory, only larger.

Joaquin laid his tools upon the ground, and took one of the slender pith rods from me. Holding an end of the rod in each hand, he stooped down near the base of the tree, and encircled it with his arms. The pliable rod bent around the bark, and the old man overlapped the ends on the far side nearly a foot higher up the tree than the middle which faced him. He drove wooden spikes, cut from palm midribs, through the overlapped ends, and through the pithy rod into the bark at intervals of 5 inches, thus securing the improvised band to the tree. From the gourd bucket he took some of the white clay, and with it puttied up the seam between the band and the bark of the tree, forming thus a smooth trough which encircled the tree at an angle with the horizontal of about 45 degrees. He replaced the unused clay in the bucket, and picking up the small-bladed hatchet cut 1-inch gashes, one directly over the other in the bark above the trough. These cuts were carefully placed and did not penetrate the wood of the tree. No sooner had this been accomplished than a thick

white juice commenced to ooze from the cuts, trickle down over the bark, to drop finally into the smooth inclined trough, and run down it to the lowest part. Joaquin quickly spiked a small leaf cup below the lower point, just as a tiny bead of white liquid fell. Other drops followed. The old man had been very skilful in his operations, hardly losing a moment. The whole task had been accomplished in three minutes.

PITH BAND SPIKED TO THE RUBBER TREE AND THE LEAF CUP BELOW CATCHING THE DRIP

We took up our tools and moved on to stop later at another tree, larger than the first, which already had a band around it and showed by the swollen and scarred trunk that it had been cut for many years. It took Joaquin but a moment to fasten a cup below the dripping point and cut fresh gashes in the bark above. Then we moved on. The next tree had a band and a cup half full of watery milk which had been diluted by the rain of the previous day. The cup was emptied on the ground and refixed to the tree. Fresh gashes were cut, and we moved on again.

During the morning we passed 105 trees, most of which had bands already in place, and some of which had cups attached. Others which had not been previously bled had nothing. Whatever was lacking was attended to.

It seemed that everything that Joaquin needed in his business could be had in the surrounding forest. When a certain thing gave out he needed but to pause, look around into the forest growth, choose a certain specie of plant or tree, and go and get the material from which he could fashion the necessary article. The bucket which he carried was a good example. It was made by slicing off the top of a large *cuia* fruit about 10 inches in diameter, scooping out the inside, and binding strips of *tucun*, a fiber made from a palm leaf, about it, drawing the ends up over the top and tying them into a handle.

When we had come to the end of the trail, we paused to rest beside a cool, clear brook. After half an hour or so, we stretched our limbs, picked up the gourd bucket and small hatchet, and started back over the trail.

As we passed each rubber tree Joaquin with hardly a pause emptied the collected milk from the leaf cups, replaced them, and was on to the next tree. As we drew nearer the trees which we had first visited on our journey into the forest, the cups became fuller and fuller, until, finally, the last tree had a cup that overflowed. The pail by that time was full of thick white milk—1 gallon of liquid rubber.

When we arrived at the egarupe, Joaquin took off his clothes and plunged into the water to cleanse and cool himself. Then we poled down the stream, drifting sometimes, listening to noises, and talking. I stuck my finger into the white liquid, and held it into the sunlight for a moment. The coating turned yellow and hardened, until I was able to peel it off as though it had been the finger of a rubber glove, and it was elastic.

"When do you cut the trees again—to-morrow?" I asked my companion as we came in sight of his clearing.

"No, senhor, it is not necessary to cut them again until day after tomorrow. You see it is this way: On the first day the milk does not run very well, and we only get 1 gallon of milk. Tomorrow we will get more, perhaps 6 quarts, because on the second day the milk runs better. But on the third day it must be cut again."

"And how many years can you take milk from a tree?" I asked.

"That depends, senhor. I am very careful, and have been cutting some of the trees for 12 seasons. I begin at the bottom; the first season uses up about a foot of the trunk near the base. The next season I begin a foot higher, and so on. After several years the band is so high up the tree that I have to build a scaffolding to reach it; then I begin at the bottom again.

The little canoe slid up on the bank, and we got out. Joaquin carried the bucket, and I followed him over the narrow trail that twisted in and out between banana palms. We came to a mud hut with a palm-thatched roof, and the old man stepped graciously aside and with a wave of his hand bade me enter and make myself at home.

After a meal of pineapples, bananas and coffee, Joaquin took up a bucket of latex that his wife had brought in, and with his own full gourd led the way to the edge of the forest, while his son, Joan, and I followed. In a few strides we came to a small clearing, where the ground was covered with ashes. There was a shallow hole in the center of the clearing, and beside it lay a large metal pan.

Joan went into the surrounding woods and returned shortly with an armful of short lengths of reddish wood, while Joaquin

BALL OF RUBBER REVOLVING IN SMOKE FROM THE CONICAL FLUE

The milk coating turns yellow and hardens almost immediately. It then goes over the pan for a new coating

made a small conical-shaped fire in the hole. The wood split easily into pieces and was laid against the fire upright. Over this was placed a conical hood of iron, the apex of which had been truncated, and a round piece cut out of the edge of the larger circular base. This hid the fire from view. Air, entering through the cut in the bottom, blew the flames within the

hood and sent a column of heavy smoke up through the small opening in the top.

The metal dish was held over this smoke for a few moments, bottom upward, and a skim which had formed around the inside from the residue of previously contained rubber latex was torn off. It had the feel of a thin sheet of rubber almost as it is sold in the stores. Then the newly collected milk was poured into the pan and the vessel was shoved up close to the smoking flue. Joaquin squatted down beside the tub of milk and dipped the smooth flat blade of a paddle into the liquid, coating it completely white. He removed it from the milk and held it, after allowing it to drip for a moment, in the smoke, turning it over and over so that all sides would be evenly touched by the smoke. The white coating gradually began to turn a creamy color and to harden. The paddle blade was dipped into the fresh milk again and recoated with liquid. Again it was held in the smoke, and again as the acid in the smoke touched the alkaline latex it coagulated it into a dry, elastic coating. These operations were repeated many times until there was a quarter of an inch coating over the blade.

With a sharp knife Joaquin then cut half way around the paddle edge, and ripped the covering from the blade. This he spread out like a mat and rolled it around the center of a short, strong pole, and made it secure with strands of tucun fiber. Then this wrapping was held over the pan of milk, Joaquin holding one end of the pole and his son grasping the other on the opposite side of the pan of milk. Joaquin scooped up a gourdful of milk and poured it over the wrapping, coating it white. Then they moved the pole over the smoke and hardened the thin covering of juice. Then it went back over the pan, and a new coating was added, and again the smoke was allowed to harden it. This process was repeated for over an hour, and gradually the mass in the center of the pole enlarged and took the shape of a large ball, which grew larger and heavier with the addition of more milk, and contact with the acidic smoke.

A FINISHED BALL OF CRUDE RUBBER

"From a gallon of milk 2 kilos of rubber can be made," Joaquin told me. "Today we will make about 4 kilos from all the milk. In 1906 we got 15 milreis for each kilo; now the Portuguese pays us only 2."

A week later a trader in a blue batalao poled and paddled his way up the river and announced himself on a loud-sounding sea shell. Joaquin and his son came over shortly with a small ball of rubber weighing 10 kilos.

"Twenty-five milreis!" said the trader, "What do you want?"

"Money only," replied Joaquin.

"Money only?" questioned the Portuguese, as though he did not like the idea at all, and he did not, because he would be cutting his profits in half. "Don't you want something else? I can only let you have 10 milreis in money; you'll have to take the rest in goods."

Joaquin bought three yards of cheap calico, stiffened with flour, a small box of tobacco, a box of matches, and each of them took a drink of *caxasa*. Usually they take a good part of their pay in *caxasa*, a watery looking drink made from cane juice that is so strong that, to quote the familiar expression, one uses alcohol to dilute it.

As it took them three days to make that much rubber, which brought 10 milreis, 3 yards of cheap cloth, a 5-cent box of matches, with 25 cents worth of *caxasa*, one has to pause a moment to reckon how many days they would have to work to buy a pair of shoes—but fortunately Joaquin doesn't wear shoes.

This old man, his son, and his woman are but three of many hundreds of poor natives who are working during five months of the year, November to March, seeking out the wild trees and taking their milk. They represent the one-man way of producing rubber, and they are, in a way, typical examples of the one-man way of doing anything in these days of highly concentrated industry. From them and their very crude methods grade the wealthier and better equipped gatherers, men who are able to employ a few helpers—from Indian tribes mostly—and the larger company holdings, where trees are cultivated and bled by highly paid labor. But compared with eastern development these are all mere infantile industries.

When I returned from the interior I found the people of Manaos very elated. "What is the matter?" I asked a friend whom I met on the street.

"Oh, senhor, have you not heard?" he asked, joyfully hugging me and patting my back after the custom of the country, "The cable reports that there is an insect that is killing all the rubber trees in the East, and soon there will be none left in Java, Siam or India—isn't that good news, senhor?"

If it were true, I'd say it was good news—for Brazil.

But leaving aside all questions of plagues, and of waiting for some kind power to kill the rubber trees everywhere except in Brazil, the word I have to give my friends in Brazil is: "Wake up." Unless they are to relinquish all control in one of the greatest industries of the world, they will have to cultivate extensively the *hevea braziliensis*, that noble tree which thrives best in its native land, but which can be made to yield profitably in other climes if the commercial needs of a quickly moving civilization demand more material than Brazil is able to supply.

DYER'S FORMULA CARD

THE National Aniline and Chemical Company has issued a very useful pamphlet which will aid the dyer regardless of his special field in producing the season's shades. The particular dyes recommended in each case have been selected with the object of obtaining the best results in the various materials which are offered for dyeing.

The following summary shows the field covered by the publication:

1. Dyeing on Silk with Acid Dyes.
2. Dyeing on Cotton.
   (a) With Direct Dyes.
   (b) With Basic Dyes.
   (c) With Direct Dyes Topped with Basic Dyes.
3. Dyeing on Woolens or Worsteds with Acid Dyes.
4. Chrome Colors on Woolens; Top-Chrome Method.
5. Dyeing on Leather.
   (a) On Chrome Tanned Calf Skin Sumac Bottom.
   (b) On Vegetable-Tanned Sheep Skin.

SPECIMEN OF NEREOCYSTIS FROM ALASKA. NOTICE LENGTH OF PLANT
(Photo by courtesy of Professor Rigg, Univ. of Washington.)

Indian Uses of Kelp

Fishing Lines, Bottles, Toys etc., Made from Seaweed

By J. C. Leachman

SEAWEEDS have been employed in many parts of the world and for many different purposes. In Japan they have become the basis of an important industry, being used for many different technological purposes and for food. The inhabitants of Norway, Denmark, Scotland, Ireland, France, Tasmania, China, and Formosa are only a few of the many peoples who have made use of algæ as a source of food and many other things. The prominence of kelp as a source of potash for European nations during the recent war must not be overlooked. Perhaps nowhere, however, have seaweeds been put to such diverse uses as among the Indian tribes of the North Pacific Coast.

Several Indians in the Puget Sound district have been questioned, but none of those now living seem to have used kelp or any other seaweed themselves. All informants had however heard of its use by other Indians in the old days. Only one object made of kelp has been seen by the present writer, a fishing line in the University of Washington State Museum, and this specimen is very dry and brittle. The temporary nature of the utensils for which seaweeds were used, the ease with which new supplies were obtained, and the perishable nature of the material would all account for the comparative rarity of museum specimens.

Several varieties appear to have been in common use, among them: Macrocystis pyrifera, Nereocystis leutkeana, Pelagophycus porra, Porphyra laciniata, Rhodymenia palmata and Ulva latissima. The first three of these are commonly lumped as kelp. This word was originally applied to the slag resulting from the burning of heaps of Fucus and other seaweeds for the purpose of obtaining potash, iodine and other chemicals. Later the term kelp came to be applied to various large seaweeds, usually brown in color, which form a very conspicuous item among the jetsam remaining on the beach after the tide has gone down. It is worthy of note in passing that the origin of the word kelp is not known.

Macrocystis pyrifera, also known as black kelp or devil's apron, is found from Magdalena Bay, Mexico, to Sitka, Alaska. It is found as a rule associated with Nereocystis leutkeana, but growing in deeper water. It often attains a great length and plants measuring as much as 1,000 feet have been reported. It usually grows in water which is from eight to fourteen fathoms deep and in common with other varieties of kelp, requires a rocky bottom as well as considerable and continuous movement of the water. It is anchored to the bottom by an immense holdfast, which often exceeds three feet in diameter, and from which extend a number of stipes or stems, which are seldom more than half an inch thick and are frequently fifty feet long. At intervals of less than a foot along these stipes grow small oval bladders or pneumatocysts from each of which springs a leaf-shaped frond about two feet long and four inches wide. The plant appears to be a perennial and grows from spores which ripen at some distance below the surface. It does not seem to have been used by the Indians as much as some of the other species, probably on account of the numerous offshoots from the stipe which rendered it less serviceable.

Nereocystis leutkeana is known as brown kelp, bladder-kelp and sea-otter's cabbage. It was used far more than any of the other seaweeds and is the species usually referred to when kelp is mentioned. It closely resembles Macrocystis pyrifera in type, except that there is only one stipe springing out of the holdfast. This is hollow for a third of its length, a feature wherein the greater part of its usefulness lay. The stipe is terminated by a pneumatocyst about five inches in diameter and separated by a slight constriction. From the bulb branch out numerous fronds, narrow but often of great length. In a specimen of average growth the first forty feet of the stipe will be solid, while the remaining hollow portion or apophysis attains a length of about twenty feet. The plant is an annual and grows from spores which in the Puget Sound district are ripe about the middle of May. It requires the same conditions for growth as Macrocystis pyrifera, that

FULL-GROWN PLANT OF ALARIS FISTULOSA
(Photo by courtesy of Professor Rigg)

is to say, a rocky bottom to afford anchorage for the holdfasts and enough movement of the water to bring the requisite quantity of nutritive chemicals within its reach. The distribution of the plant is wide, reaching from a little south of Point Conception, California, to the Arctic and to the shores of Kamchatka.

Pelagophycus porra, known also as elk-kelp, sea-pumpkin or sea-orange, was formerly known as Nereocystis gigantea. Its distribution seems to be more limited than is the case with the other kelps. It is said to occur not much more than a hundred miles north of San Diego Bay, in California, and extends from this point southward. It closely resembles Nereocystis leutkeana in every respect except that the pneumatocyst is larger, sometimes twice or three times as large, and from it spring horn-like, frond-bearing stipes, from which fact it gets its name of elk-kelp. It appears also that a larger proportion of the stipe is hollow than is the case in Nereocystis.

Porphyra laciniata, or purple laver, was used by the Indians in conjunction with the green and red lavers. It is occasionally gathered by the Chinese resident on the Pacific coast for food. It grows between tide marks on rocks and stones, the fronds, which spring from a common holdfast, resembling delicate ribbons. Rhodymenia palmata (or dulse), the red laver and the green laver, Ulva latissima are also used by the Indians. They resemble the purple laver on superficial examination in all respects but color.

The use of seaweed for food seems to have been a common practice in many parts of the world. It is still so used in Ireland and Scotland and, more seldom, in England, while Japan bases a large industry on the gathering and preparation of various seaweed products such as kanten, kombu, wakame and various forms of nori, the latter being the generic name for seaweeds. China, Hawaii and many other districts in the Pacific Ocean also give it a place in their dietary and in this regard the Indians of the North Pacific Coast were not exceptional. The Indians in California, especially those living a few miles inland, made periodical excursions to the beach to gather seaweed and searched especially for the large stems and bulbs of kelp. It is probable that the salt was one of the things sought. That this was not the only reason appears from the fact that the Indians of Fort Ross, California, formerly gathered large quantities of kelp from the beach and used it in making a soup which they prized highly. Swan states that dulse, while not in common use, was an article of diet among the Haida Indians of Queen Charlotte Islands and other tribes. Bancroft mentions that seaweeds were prepared for use in winter; this was probably done in the manner described by Swan, who says that green and purple laver and dulse are compressed into blocks and sliced up with a sharp knife as needed. Bancroft also says that some varieties, such as eel-grass, were eaten raw. Reference has already been made to the salt obtained by the Fort Ross Indians in California from algæ. A more direct method of securing this substance was that employed by the Indians of the San Juan Islands, north of Puget Sound. The fronds of the kelp were laid on clean drift logs and exposed to the sun, with the result that efflorescence of the salt occurred which was then easily collected and stored in suitable receptacles.

More or less closely connected with the subject of food is that of drink and here also the kelp proved of use. Rigg states that the apophysis is used as a "worm" in the preparation of "hoochena," a drink popular among the Eskimos. Stone-cooking was a method very generally employed in this culture area, and we are informed by Swan that seaweed, probably of the laver species, was used to prevent direct contact of the hot stones with the food. Fern leaves were also used for this purpose.

In connection with the use of seaweed for food, it should be noted that it has been used in Europe as an emergency ration for cattle, sheep and horses, and that deer have been seen eating it in times of scarcity. The natives of Kodiak Island, South Alaska, also used seaweed for feeding cattle, particularly afte rthe Katmai eruption had destroyed most of the pasturage.

Perhaps the use of kelp which involved the least preparation was its employment as bait. A section of the stem was weighted with a stone and let down to the bottom of the water with a line and buoy attached. This was allowed to remain for some hours and was then gently drawn up into the canoe. If the fisherman were fortunate he would find a sea-urchin feeding on the kelp. These animals are still used for food by various Indian tribes, but not in such large quantities as formerly. Another use which involved no more elaborate preparation than the severing of the bulb from the stem, was that in which the bulb served the purpose of a bait-holder, keeping the bait cool and moist. A similar utensil was used as a bottle for carrying water on fishing expeditions. The use of the bulb as a bottle seems to have been fairly widespread; they were used in South America and Tasmania as water-bottles, while in New Zealand the pods of a large seaweed were used by the natives to store whale-oil which they used in the lamps in their sleeping-rooms. These, when filled, held about a quart of oil each, were tied at the neck with flax fiber and resembled in appearance a bottle made of rubber. They are still used in the Puget Sound district to contain fish-oil, used both as a sauce and for preserving fishing tackle.

Kelp also played its part when the canoes were overtaken by rough weather. It was, and for that matter still is, a common practice to tie the canoe to a number of growing kelp plants and let her ride there till the storm abates. Among the Eskimos the apophysis is used as a siphon for emptying the water out of their kayaks, which, being decked in, are not readily baled out in the ordinary manner.

It is well known to the people of the North Pacific Coast area that many kinds of wood can be readily worked into desired forms after being heated in a fire or steamed. An ingenious process involving this fact is employed by the Makahs at Cape Flattery. In making halibut hooks, knots of hemlock are first shaped with a knife and then inserted into a hollow piece of the stem of the kelp and roasted or steamed until they are pliable.

The use of kelp for fishing lines on the Northwest Coast is frequently referred to in the literature and seems to have been spread from the coast of California to that of Alaska. It was stated by MacMillan in 1899 that such lines are still preserved as curiosities by a few native fisherwomen. Swan's account of the manufacture of these lines, which are principally used for taking halibut, deserves to be quoted in full:

"Fishing lines are made of the kelp-stem. This is collected by two sticks joined together like the letter A. At the bottom a stone is secured as a sinker; five or six inches above the stone a knife-blade is fastened between the two sticks and a line is then fastened to the upper end. This instrument is slipped over a bulb of kelp, lowered to the bottom and a slight pull severs the stem close to the ground. They usually prefer the kelp growing in ten or twelve fathoms of water; most of the stems, however, that they procure rarely exceed ten fathoms in length and many are not over five. For more than half its length the stem is hollow, but this section is not taken for lines. When a sufficient number of stems have been cut they are placed in fresh water—a running brook being always preferred—where they remain for five or six days, or until they have become bleached nearly white. Then they are partially dried in the smoke and knotted together at the ends, and further dried in the sun, after being stretched to their full length and their utmost tension. This reduces their size to that of a cod line. They require several days' exposure to the sun and air before they are sufficiently cured. They are taken in every night while curing and are coiled very neatly each time. When perfectly dry they are brittle, but, when wet, they are exceedingly strong, fully equal to the best cod lines. The usual length is from eighty to one hundred fathoms, although it is seldom that fishing is attempted at that depth, except for 'be-sho-we,' the black cod; and the probable reason for their being so long is to guard against accidents by which a portion of the line may be lost. When fishing in shoal water it is usual to tie a portion of the line at the required depth and lay the remainder on one side, so as not to endanger its being entangled by any fish that may be caught. Lines for small fish are made from kelp stems of the first year's growth which are about as large as pipe stems." It is interesting to note that fishing lines made of Chorda filum were used in Scotland until quite recently.

Seaweed is also used in the construction of houses, where it is employed in "chinking" the cracks in boards and the interstices between logs. This would probably be a use confined to the smaller species, some of which when dry make a sort of natural excelsior packing. The eel-grass which is often found washed up on the shore was used to produce the white parts of the pattern in basketry and is still so used to a limited extent by the Indians at Cape Flattery. It is bleached in the sun before being woven into the baskets.

Toys were also made from kelp, the children using sections of the stem to make the wheels of toy wagons. It was also used by the boys in a game in which they imitated the killing of a whale, towing a long kelp-stem along the beach and darting harpoons into it until it was split or the supply of harpoons exhausted.

Kelp and other seaweeds have been used from time immemorial as fertilizers and it is noteworthy that the time for gathering seaweeds that have been cast up on the beach is regarded as a festal occasion in France, Scandinavia and the New England Coast of the United States. The natives of Kodiak Island invariably use Nereocystis and Alaria fistulosa as fertilizers for their gardens, but it is practically certain that this use was not known till the introduction of vegetables by the whites.

Kelp seems to have had its uses in medicine also. The Indians at Sitka use the hollow portion of the kelp to cure headache. The smaller end is placed in the ear and the other against a hot stone, which results in the production of steam from the water in the kelp. At Neah Bay, among the Makahs, portions of the bulb are used by nursing mothers as a poultice for caked breasts and it is said to be soothing and antiseptic. The apophysis is also used according to one informant of the writer's to give an enema of oil. It should be noted that agar agar, which is of so much importance to the modern medicine man, is a seaweed product, being made from the genus Gelidium.

Seaweeds were used in several ways in ceremonials. Amulets were in constant use and one of the most powerful of

SECTION OF BULB OF NEREOCYSTIS SHOWING ITS UTILITY AS A BOTTLE
(Photo by Professor Rigg)

FISHING LINE MADE FROM NEREOCYSTIS. SPECIMEN IN UNIVERSITY OF WASHINGTON STATE MUSEUM
(Photo by the author)

these was a belt of seaweed tied in magic knots. No information seems to be available as to the kind of seaweed used for this purpose or the type of knots, but it seems probable that kelp would be used as few other species would be suitable. On war expeditions it was customary to wear the hair tied in a knot at the back of the head and into this knot were thrust sprigs of evergreens, but on ceremonial occasions the evergreens were replaced by wreaths of cedar bark or seaweed. It may be mentioned here that seaweed has ceremonial uses in Japan also and that kombu, a food made from seaweed, is said to be a symbol of a gift.

One of the most ingenious schemes of all was that in which a shaman convinced the beholders that he was able to speak with a spirit which inhabits fire. For this purpose a shallow trench was dug in secret from the fire, either to the outside of the house, or if the proceedings were to be out-of-doors, to a convenient rock or bush. The hollow portion of a kelp stem was buried in this trench, which was then carefully filled in and all traces of it obliterated. A confederate was thus enabled to keep up a telephonic conversation with the operating shaman, while the effect on the astonished onlookers may be readily imagined.

It is quite probable that there are some uses to which kelp and other algæ were put that have now been forgotten, but it seems safe to say that there is no other single material, with the exception of cedar, which was put to such a large variety of uses or filled a position of such great economic importance with these people.

The Ionic Dissociation Theory

Some Interesting Experiments for the Amateur Chemist

By Albert T. Fellows

MOST lovers of chemistry are familiar in an offhand manner with the Ionic Dissociation Theory; but very few thoroughly understand this theory. This situation is really to be deplored, for this theory is such a potent weapon in the hands of either the chemistry pupil or the eminent chemist. The purpose of this paper therefore is to familiarize the student with this theory; not by giving the theory alone and having him memorize it, but by teaching it in the language of Nature—by experiment.

First of all, it seems advisable to give the elementary principles of the theory before studying the details and performing the experiments. The principle points of the theory follow.

I. Arrhenius, in 1887, was led by various phenomena to advance the theory that some compounds break up or dissociate when dissolved in water. A portion, at least, of its molecules break up into two parts. One of these is charged with positive, the other with negative electricity. These charged particles are known as positive and negative ions.

As an example, when we put salt (NaCl) into water, dissolve it as we say, it disappears. The first part of our theory tells us that a certain number of the salt molecules are broken up or ionized into ions of $Na^{\bullet}$ and Cl'. The ($^{\bullet}$) indicates a positive, the stroke ($'$) a negative charge of electricity. Unless our solutions are very dilute, they will contain along with the ions the substance in molecular form. Then our solution really contains the following, NaCl, $Na^{\bullet}$, Cl', H_2O, $H^{\bullet}$, and OH'. That is the water is also slightly ionized, and if the ions of water are present in sufficient quantity, they will combine with $Na^{\bullet}$, and Cl' to form hydrochloric acid ($H'Cl$) and sodium hydroxide (NaOH). These last two substances are only theoretically present since in the extreme dilution they remain dissociated. Please notice that the ion differs from the atom in that it has an electric charge, which profoundly alters its properties.

II. The proportion of molecules dissociated in a given solution at a given time depends upon the nature of the solute, the dilution of the solution and the temperature.

III. All reactions between acids, bases and salts in aqueous solution are invariably reactions between their ions.

The student must not come to the conclusion that this is all of the theory, for it is not. However, it is enough for the amateur chemist if he will only perform the experiments thoughtfully. For they will involve all of the common principles of the theory.

The part of the theory most familiar to the experimenter is the section devoted to electrolysis. I think a few experiments will make the terms and principles of this portion clear.

Fill a U-tube with a solution of copper sulphate. This dissociates and is called the electrolytic (note that the ions this time are $Cu^{\bullet}$ and SO_4'). Electricity from a few dry cells is passed through the copper electrodes, the electropositive copper ions ($Cu^{\bullet}$) move to the cathode or negative electrode and the electronegative sulphate ions SO_4') go to the anode or positive electrode. The copper ions when they reach the cathode give up their electric charges and become metallic cpper. The sulphate ions (SO_4') when they reach the anode, upon giving up their charges, by uniting with water and setting oxygen free, become sulphuric acid. The oxygen comes off in small bubbles. If we examine our U-tube we see that such is the case. We see the bubbles coming off from the anode and the surrounding liquid steadily loses its color, while the cathode is covered with copper and the color deepens. This is well shown by Fig. 1.

The experiment illustrates the migration of ions and how electricity is conducted through a solution.

A question is perhaps suggested by the first part of the theory. Are there free ions in a solution of an electrolyte? Ostwald answered this question by means of a fascinating experiment. An adaptation of this classical experiment may readily be performed by the student.

Set up a U-tube as shown in Fig. 2 and fill it with dilute sulphuric acid. A rod of zinc which has been amalgamated by rubbing with mercury is lowered into the arm at A. This is the positive electrode or anode and must be connected to the zinc of the battery. A copper wire is inserted into the other arm and connected to the carbon of the battery. A current produced by three or four wet cells is then passed; there is an immediate evolution of hydrogen from the copper wire. Zinc sulphate is formed at A. This is also shown by Fig. 2.

This is very strange when we remember that if there was no current the hydrogen would be evolved at A. So if the hydrogen had to pass around the bend of the U-tube it must have done it in a very short time. However it has been proved by investigations and the calculus that it would actually have taken hours for the hydrogen to come from *A* and appear at *B*. The hydrogen however appears as soon as the circuit is closed. The natural explanation is to suppose that there are free ions already in the vicinity of *B* and that they are discharged by the current and given off from the liquid as free hydrogen.

Although at first thought this experiment does not seem so marvelous, when one considers what a great truth it teaches and its simplicity, he will very often change his mind.

We must now consider what our third division of the theory means. Ostwald has clearly pointed out four methods by which ions are formed. One of these is by the dissociation of molecules into ions in the presence of a suitable solvent. Now recalling to mind our third principle, that, all reactions are due to ions, several experiments are at once suggested. One of the best is very simple and yet convincing.

Mix in a test tube equal amounts of dry ferric ammonium sulphate and potassium ferrocyanide. There is no sign of a chemical reaction; but add a little water, a blue precipitate is

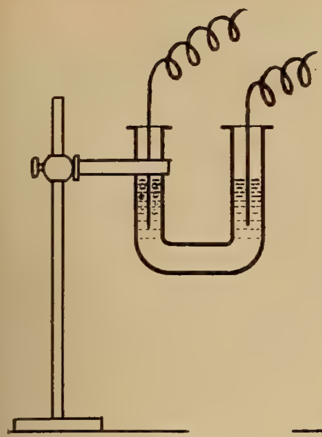


FIG. 1

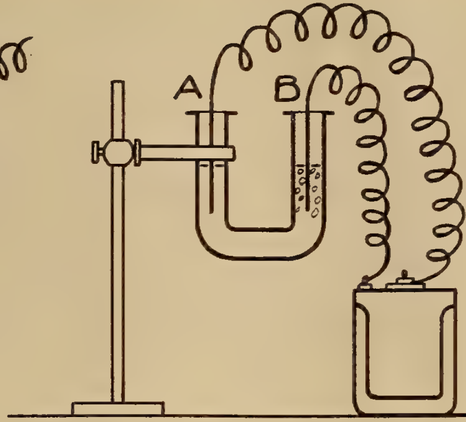


FIG. 2

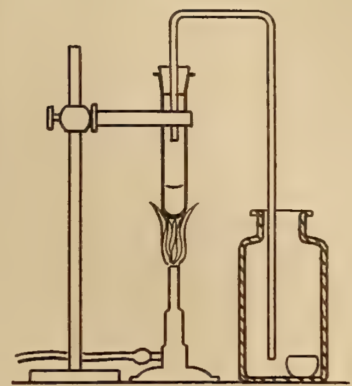


FIG. 3

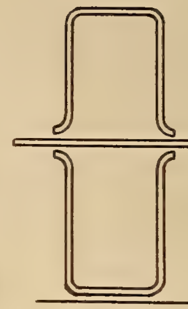


FIG. 4

thrown down. We have ionized the two salts and then they react but not before.

Let us extend this same line of reasoning to gases. This is more perplexing for under ordinary conditions we have both molecules and ions. This is due to the slight amount of water vapor always present in the air. The obvious thing to do is to exclude the ions and have nothing but molecules present. Then there should be no chemical activity. The removal of ions thus reduces itself to the removal of water.

Ammonia gas from which all of the ions are removed ought not to turn litmus blue. Here we must bear in mind that the ions are formed by action of ammonia and water, thus $NH_2 + H_2O = NH_4' \; OH'$. Here we see the basic OH ion and it was formed when we added water. Now if we can remove the water from ammonia gas it ought not to exhibit a basic reaction.

All that is necessary to do this is a bottle, some extra dry quick-lime, litmus paper and ammonia. We suspend the red litmus paper in some convenient manner in the bottle, generate the ammonia gas by warming some ammonium hydroxide and conducting the ammonia gas into the bottle (see Fig. 3). Inside the bottle is a small crucible which contains the quicklime. The litmus is now blue, exhibiting the regular basic reaction showing the presence of ions and therefore water. But the thirsty quicklime is already doing its work and in two days, or three at the latest, the litmus is red. Think of it, litmus paper showing an acid reaction in the midst of one of the strongest bases—when it has all powerful water!

Again let us repeat our experiment using hydrochloric acid gas instead of ammonia and blue litmus for red. We must use phosphorous pentoxide as the drying agent. The apparatus is the same as before; but the reaction is different, *i.e.*, the litmus turns red when the acid gas is generated.

Now while we leave our gas to dry, we will try another experiment. Take two beakers of equal size and fill one with hydrochloric acid gas and the other with ammonia. Place one over the other separated by a piece of glass (see Fig. 4). They are both clear. Remove the glass and allow the two to mingle. There is a white cloud formed which if permitted floats lazily about in the air.

You will note that we took no care to dry the gases and that there was a very vigorous reaction, indicated by the white clouds.

Let us return to our hydrochloric acid gas: if it is highly dried, the litmus turns blue just as it turned red in ammonia, *i.e.*, in opposite directions to what is expected. If both gases are highly dried we may mix them; however, if we have taken care not to expose the open bottles to the water of the atmosphere, we will only have a slight cloudiness at most.

Like the proverbial lamb and the lion, these two gases, ammonia and hydrochloric acid having such a great affinity for each other remain side by side inactive. It is truly wonderful! To further confirm our theory allow access to the air; the dry gases begin to fume because of contact with the water vapor of the air.

Some other experiments of a similar nature at which the youthful scientist may tax his skill and find himself well repaid if he succeeds are:

Dry chlorine does not act on fused metallic sodium.

Dry sulphur, boron and phosphorus do not burn in dry oxygen.

Dry hydrochloric acid does not attack carbonates.

One of the most conclusive experiments of all was performed before the Chemical Society of London. A wire serving as a handle was wrapped around a piece of dry metallic sodium, which was then plunged into pure, dry sulphuric acid. At first there was a flash of light caused by the few ions formed on the surface of the metal as it moved through the air to the acids. After that the sodium remained suspended in the sulphuric acid as if it were so much kerosene. A hint of what would happen if ordinary chemicals were used is given by that first flash of light. I am afraid that it would wreck some real estate.

The above experiments and many others which I might mention show conclusively that molecules have little or no chemical activity, and that ions are the chief agents causing chemical actions. We can now see why inorganic reactions proceed rapidly to the limit, while organic reactions take place more slowly. The inorganic compounds contain the strong bases, acids and salts which are strongly dissociated compounds. Thus there is an abundance of ions and that means lively reactions. Whereas the organic compounds are weakly dissociated and the reactions proceed slowly because of the few ions present.

CARBON-DIOXIDE AS A FERTILIZER

Some very remarkable experiments have recently been made in Germany, with a view to ascertaining plant growth, by furnishing plants with artificial supplies of carbon-dioxide or "carbonic acid gas" in addition to what they ordinarily obtain from the atmosphere. The idea is to irrigate fields with carbon-dioxide obtained from the exhaust gases of motors and furnaces. An account of the process employed is given by a German scientist named Riedel, in the German engineering journal, *Stahl und Eisen*. The first tests were made in a hothouse, the gases being diluted until they contained one half of one per cent of carbon-dioxide. This additional carbon in the atmosphere produced unexpected results, the yield of cucumbers being twice as great as in the control plants and that of tomatoes nearly three times as great. Equally good results were obtained in the case of plants grown outside. The carbon-dioxide was furnished here by means of perforated pipes, which traversed the field. Mr. Riedel estimates that an industrial furnice furnishing 1,000 tons of iron per day, yields a sufficient amount of exhaust gases to fertilize 4,000 tons of potatoes.

Severing Metals by Oxidation

Some Problems of Flame Cutting in Which Authorities Disagree

By Pierre E. Haynes

THE art of severing metal by oxidation is not yet twenty years old and it has been averred that our knowledge of the subject is quite complete and comprehensible. Its companion, the art of welding, is several thousand years old and its first practice has marked the birth of every civiliation on the face of this planet. Who will venture that with all this ancient development and modern research, the world's knowledge of welding is complete and comprehensible not to say simple!

The art of severing metal by oxidation is in its infancy. We know we can cut some metals because it is being done but the exact mechanism of cutting is not yet well understood.

Only a year ago the published word of erstwhile authorities contained statements that cast iron could not be severed by the oxidation process. Three and one-half per cent of carbon, the self-same material that furnishes the artificial heat of the world prevented oxidation of iron. Why couldn't iron be oxidized in the presence of carbon when carbon is more easily combustible than the iron itself? It seemed so simple that a simple answer was required. Cast iron, they said, melted below its temperature of ignition and freezing slag prevented the raising of the iron above its melting point. This explanation was so generally accepted that with a few exceptions no attempts were made to develop the art of cast iron cutting.

Witness today the effective cutting of cast iron with standard equipment. Popular authorities are falling over themselves to whisper the reason in the ear of the public. As a matter of fact, men who are devoting their lives to the study of flame-cutting are not yet sure of the complete explanation. They cut and know they cut because they cut. If they loved anything better than the truth, theories far more rational than many popularly promulgated might be presented.

Because it constitutes one of the major elements of the cost of steel cutting and because it is one of the materials not prepared by the consumer himself, commercial cutters are prone to assign all variations in cutting cost or quality of the oxygen and in support of this contention present cost determination and other data which indicate the undesirability of nitrogen as an impurity. A recent writer points dramatically to the overwhelming cataclysm which would result if nitrogen were combustible. "A lightning stroke," says he, "would explode the beneficent atmosphere surrounding the earth." While not recommending nitrogen as a commercial fuel, one must remark that every lightning stroke does form nitric acid; and deposits or nitrates, at favored spots on the earth's surface, indicate that in the aggregate large amounts of nitrogen are being burned. Not to be outdone by Nature our Norwegian friends drew lightning strokes from waterfalls for the purpose of burning nitrogen to form the world's most valuable acid.

With respect to burning or combustibility, nitrogen differs from iron in measure only, and as a matter of fact, the difference is the same for practically all substances. Some substances burst into flame immediately upon exposure to air or oxygen while others like wood, usually require a flame for kindling. Iron kindles in oxygen at red heat, while a mixture of acetylene and oxygen may be ignited by allowing it to impinge on iron below its temperature of incandescence. The kindling temperature of nitrogen is high, but what careful observer has failed to detect the odor of nitric acid where steel cutting is being performed?

Oxygen is not satisfied with its ability to attack successfully its plebeian neighbors and form new substances. This aristocratic gas combines with itself and forms ozone, king of oxidizers. That it combines with itself is proven by the fact that three volumes of oxygen form only two volumes of ozone. The unmistakable odor is usually present wherever oxyacetylene cutting is being performed. Whether it enters into the actual process of cutting has never been determined. The fact remains that oxygen combines with itself with a negative heat of combustion.

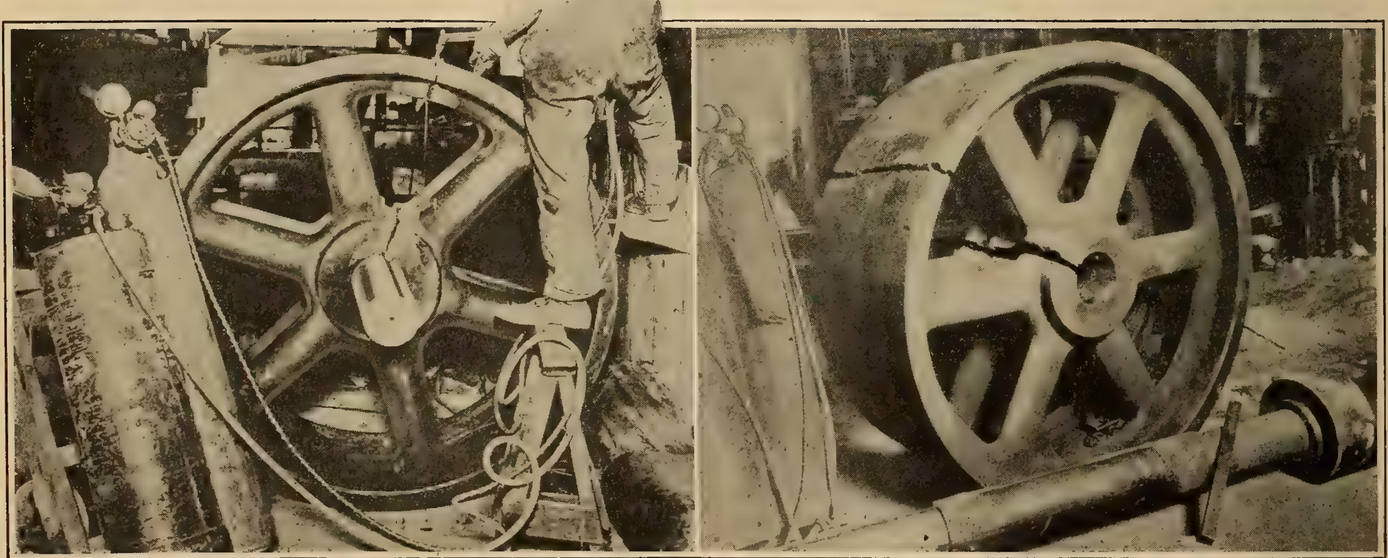
Stripped to known facts, the process of flame cutting of steel consists of the elevation of some spot to the kindling temperature, the application of oxygen and the progressive direction of the oxidizing jet along the desired path. The requirements are:

1. A preheating flame hot enough to bring the iron to its ignition point without delay.

2. The intelligent adjustment and direction of the cutting appliances to maintain highest efficiency and results of desirable quality.

3. Oxygen of suitable quality and at the correct pressure and jet velocity.

A wide range of fuels may be found to meet the first re-



EXAMPLES OF CAST IRON CUTTING—THOUGHT IMPOSSIBLE A YEAR AGO BECAUSE OF SUPPOSED CHEMICAL OBSTACLES

CUTTING OUT RIVETS TO REMOVE SHELL PLATES FROM HULL OF VESSEL

CUTTERS AT WORK ON LOWER SHELL PLATES OF A STEEL SHIP

quirement although the use of poorer fuels usually results in a greater expense for oxygen and labor.

The personal element is by far the most important in the determination of the cost of cutting. A 12 per cent variation in cutting cost, with all other conditions constant, would be considered excellent from the standpoint of reproducibility, and a 20 per cent variation is not at all uncommon for workers under ordinary observation.

The pressure and jet velocity of the oxygen are important because they determine the amount of iron oxidized and the cleanliness and dispatch with which the molten oxides are removed. They are matters of torch design and adjustment. Authorities seem to agree fairly well regarding these points but disagree with regard to the effect of the various impurities found in the commercial oxygen. Proponents of the use of electrolytic oxygen insist that regardless of the nature of the impurities the small differences in the quality of commercial oxygen is an effective element in the cost of cutting steel and that at even purity, electrolytic oxygen is superior to "liquid air" oxygen because of the combustibility of hydrogen and certain alleged villainous qualities of nitrogen. We have certain specific allegations made in a recently published article, the accuracy of which it would be distinctly improper to question without having observed the test. It is correct however to question the assumption that the variation in results is due to the quality of the oxygen if the method of test is incapable of detecting this fact.

It is stated that tests were made "with each oxygen adjusted at its own best pressure and working conditions." Long and bitter experience has taught that comparable results are never possible unless all conditions of cutting are reproduced with the exception of time for each individual determination. While it is reasonably safe to assume that each operator will adjust his appliance to the best possible conditions as they appear to him, there is no assurance that any of the operators are competent to judge this condition absolutely with the crude means at their disposal and any variation in results may as well be assigned to the difference in adjustment as to variation in oxygen purity. Scientific practice demands that all variations except the one to be measured be eliminated or considered in judging the final result. Results such as these recently published cannot be considered more than qualitative.

It has been stated that the impurities in "liquid air" oxygen suffer a much greater quantitative variation than those in electrolytic gas. While not able to speak for the whole oxygen industry I believe that I am safe in saying that there is nothing inherent in any of the so-called liquefaction processes that would prevent the limit of variations to much smaller values than those referred to. It is quite possible that the author of the recent paper is referring to commercial oxygen of several years ago. The purity of all commercial oxygen has been improved greatly in the last few years. Electrolytic oxygen manufacturers being forced to increase their purity because of the inherent risk in the compression of oxygen containing hydrogen. This risk is still present and, although in much lesser degree, is always a potential one until machines and men are rendered perfect. The cost of producing a reliably safe product is reflected in the greater cost of production of electrolytic oxygen to which attention has been frequently called.

In one of the recent articles considerable stress is laid on the advantage of electrolytic oxygen over "liquid air" oxygen because of the absence of nitrogen. The total absence of any impurity other than hydrogen is accounted for by the fact that electrolytic oxygen is made from distilled water. It would be impossible to state the total amount of electrolytic oxygen made by the use of distilled water but in as much as good filtered water has been found satisfactory it is doubtful if the use of distilled water is general. The statement that electrolytic oxygen is made from distilled water is, however, in error since it is necessary to add some substance to make the water conduct the electric current. Commercial caustic soda is usually used for this purpose and unless the soda is fairly pure there is some danger of pollution of the products. Impurities originating from the water or electrolyte are of relatively no importance, however, except for gases dissolved in the water which are sure to appear in the oxygen.

Careful analyses of electrolytic oxygen always disclose from 0.1 per cent to 0.3 per cent of nitrogen which may come from the gases dissolved in the electrolyte or may diffuse into the cylinder which stands empty with the valve open. Regardless of the source this small amount of nitrogen seems always to be present. On the other hand the impurity of oxygen obtained by means of the liquid air process, consists of nitrogen and argon—not of nitrogen alone.

CUTTING PLATES TO PATTERN IN THE SHIPYARD

If oxygen impurities are to be considered in the light of cooling agents we must consider them from the standpoint of their percentage by weight and not volume. On this basis nitrogen is approximately 50 per cent by weight of the impurity of electrolytic oxygen and 60 per cent by weight of the impurity of "liquid air" oxygen. Argon, because of its low specific heat, is much more desirable than either hydrogen or nitrogen. As a cooling agent hydrogen stands out as a notorious offender, its specific capacity for the conduction of heat being approximately six times that of any other gases in the flame.

As proof of these statements, theoretical calculations of the temperatures of the inner cones of oxyacetylene flames have been made using electrolytic and "liquid air" oxygen at various concentrations.

FLAME TEMPERATURE—DEGREES CENTIGRADE ABSOLUTE

	98%	99%	99.5%
Liquid air oxygen	5040	5050	5060
Electrolytic oxygen	5035	5048	5060

In the calculation of the above the nitrogen impurity of electrolytic oxygen was maintained constant at 0.2% (an average experimental value) in order to indicate that as hydrogen was eliminated the flame temperature of "liquid air" oxygen was approached. The percentages of the argon and nitrogen in "liquid air" oxygen were the amounts found in actual practice. The above values do not include the effect of the higher heat conductivity of hydrogen.

In practice, the above differences in flame temperatures would never be detected. They are given for the purpose of showing that small as the effect may be they are unfavorable to the electrolytic oxygen.

If we argue that the heat yielded by the combustion of hydrogen is of value we again find ourselves up against a similar condition. If we try to find the effect in the preheating flame, we learn that acetylene has at least four times the net or low heating value of an equal volume of hydrogen so that the heat added to the flame by 1% of hydrogen impurity is:

$$.01 \times .25 = .0025 = \tfrac{1}{4} \text{ of } 1\%$$

In addition to this it has been determined that the preheating flame supplies less than 30% of the total heat available in cutting, the balance coming from the combustion of the iron. The effect of the hydrogen impurity is therefore further reduced to at least

$$.30 \times .0025 = .00075 \text{ or } 75/1000 \text{ of } 1\%$$

What reputable engineer will risk his good name by assigning commercial advantage in a technical process to the addition of less than 1/10 of 1% of the available heat?

Let us then turn to the contention that the nitrogen expands and dilutes the oxygen. In the first place all gases have the same coefficient of expansion with heat and it is absolutely impossible to change the oxygen percentage in a mixture by heating it. The oxygen expands at the same rate as the impurities and no change in the constituency is possible. On the other hand, expansion (or dilution) of the oxygen would take place if the gas were perfectly pure because any gas expands to larger volume when heated at constant pressure.

And what, pray tell, becomes of the much-to-be-desired hydrogen impurity as it passes through the flame and kerf to be burned in the outer envelope? Has it not also expanded with heat; does it not also occupy space; has it not absorbed heat? In fact is there any undesirable attribute that nitrogen has which is not also possessed by hydrogen in the same or greater degree. Only one real advantage is claimed and that is the fuel value of the hydrogen, but this quantity is ridiculously small and negligible for all purposes.

Certain peculiar properties claimed for nitrogen by a recent writer include that of being expanded by heat in such a way that cooling of the nitrogen results. A student observing experiments with liquid air for the first time and being much impressed by the evolution of vapor at such low temperatures, exclaimed, "It's so hot it's cold"! So with our friend's nitrogen impurity—it is hot because it is cold and vice versa.

It seems almost impossible that claim for surface hardening on account of a nitrogen impurity in the oxygen will be accepted generally. In the first place the hardening of steel is controlled almost entirely by its carbon content and rate of cooling. If, as is claimed, nitrogen containing oxygen cuts slower than that containing hydrogen, it appears reasonable to expect that the slower operation will give the slower cooling and result in softer surfaces. In addition we must not forget that the oxygen jet aspirates large amounts of air into the kerf and that the hot surface of the metal almost invariably cools in a bath of air so that the nitrogen in the flame from the "liquid air" oxygen is a small per cent of the total nitrogen. This same set of conditions will also be found with the use of electrolytic oxygen. The preponderance of atmospheric nitrogen renders the fractional effect of the oxygen impurity negligible.

CUTTING A 44-INCH STEEL RISER

Owing to upright position of riser and consequent horizontal cut, the corners were first cut so as to reduce to smaller square cross section, the process being repeated on the reduced squares until the jet easily penetrated the remaining stem.

The question of surface hardness has not been raised previously except in connection with the use of hydrogen as a fuel instead of a hydrocarbon gas. It was claimed that hydrogen used as fuel produced a steel surface free from carbonization. At first glance the statement appeared logical but a casual analysis showed that the steel burned in the process of separation yielded sufficient carbon to account for the maximum carbonization found. A microscopic examination of surfaces cut with acetylene and hydrogen used separately as fuels failed to discover any appreciable difference in the amount of carbonization.

The carbon contents of the samples before cutting were less than 0.2 per cent and after cutting it was found that a thin layer of metal on the cut surfaces had had its carbon content increased to 0.9 per cent or greater. Carbon had been added in the case of the oxyhydrogen cut as well as that of oxyacetylene. In the case of the oxyhydrogen cut, the only

source of carbon was the steel and the amount of carbon added was fully as great as in the case of the oxyacetylene cut. It would be grossly unfair to insist that acetylene is a source of carbonization when the use of a "no-carbon" fuel results in carbonization. The carbonization was a result of the avidity of molten steel for the carbon in adjacent burning steel—the origin was the same in both cases.

The cutting of steel is approximately 70 per cent efficient or in other words the oxygen required to burn all the iron removed to oxide is about 70 per cent of that usually used. It is physically impossible to obtain complete mixing of iron and oxygen in the small time allowed in the kerf so that there will always be some oxygen and some iron uncombined. It is quite improbable that the conditions of theoretically perfect cutting will be approached closely and the possible increase in cutting efficiency is less than the advantages extravagantly claimed for some apparatus and materials. As competition grows keener and materials and apparatus approach perfection, differences will be smaller and more difficult to detect. The inability to disprove extravagant claims must not be confused with absolute proof that they are *bona fide*. Not only must experimental data be carefully studied but they must be considered in a rational, reasonable manner, free from bias and devoid of that amateurish enthusiasm which is generally present where new and interesting lines of investigation are being opened up. One can always find technical differences because they are always present and we should always question ourselves as to their relevance and measurable effect.

Upon the shoulders of the engineering profession is a great responsibility. The great complication of our industrial life demands interpreters who not only comprehend the facts but sense the value of a true and accurate translation of them into terms generally understood. This is one of the functions of the engineer—the rational interpretation of technical information in the light of fundamental scientific principles.

Metal Substitutes—II*

Use of Various Metals and Alloys in Germany to Replace Those Made Scarce by the War

By General Director Albert Wuerth

With Annotations by C. Powell Karr, Ph.B.

(Concluded from Our Issue of January, 1921, Pages 54-58)

Up to the introduction of a zinc alloy for which already a continuous investigation had been arranged, brass was specified. This reversion resulted in slowing up the output from the foundries and workshops. The tensile properties were always good, but were kept just within the limits demanded by the analyses. Simultaneously there was an investigation in process to make a cast-iron serviceable for fuses which will be reported later.

After the first failure with zinc fuses there came into consideration chiefly copper and aluminum as ennobling additions to the zinc alloys. They were regarded as inferior in tensile strength by Engineer Schulz (see Schulz's experiments concerning a method for the improvement of zinc—*Metall und Erz*, 1916, p. 279) which will be referred to later. The known binary alloys in the first place may be distinctly recognized by the reaction of a single metal such as aluminum or copper upon zinc.

An addition of 3 per cent aluminum gave a rupture charge of 5 to 6 kilograms per square millimeter, or (7,112 to 8,534 lbs. per square inch), 4 per cent a rupture charge of 9 to 12 kilograms per square millimeter, or (12,801 to 17,068 lbs. per square inch)

Six per cent gave a rupture charge of about 16 kilograms per square millimeter or (22,757 lbs. per square inch) with a corresponding increase of hardness.

The ternary alloys of zinc, copper and aluminum with an addition of 0.5% Cu. plus 1% Al. gave a rupture charge of 5 kg. per sq. mm.

2.0% Cu. plus 3% Al. gave a rupture charge of 10 kg. per sq. mm. or (14,223 lbs. per sq. inch)

3.0% Cu. plus 6% Al. gave a rupture charge of 15 kg. per sq. mm. or (21,335 lbs. per sq. inch)

4% Cu. plus 9% Al. gave a rupture charge of 20 kg. per sq. mm. or (28,446 lbs. per sq. inch)

6% Cu. plus 10% Al. gave a rupture charge of 25 kg. per sq. mm. or (35,560 lbs. per sq. inch).

After the reversion to brass, several alloys were very soon recommended, which after making a selection were immediately introduced.

The structure of No. 1 alloy (see Table on page 147) revealed stem-like branches at the margins or edge. The cohesion of the individual crystals failed partially. In consequence of the coarse crystallization of the structure the foam cells were strongly developed. The tenacity was low. Within and at the boundaries of the crystal aggregates fractures appeared. The structural aspect of Alloy No. 2 is like that of the aluminum-copper alloys. The structure consists of small crystals upon the cast surface that are distinctly visible. Here also appeared skeletons of solid solutions.

In the No. 5 alloy (see Table) the structure allows the same remark to be applied to it, yet here the composition is only a little above the eutectic (5%). Indications of segregation, in addition, were perceptible, although in small quantity.

From the exhibition of the chilled structure of the aluminum-zinc alloys it is to be gathered that an aluminum content of 5 per cent lies along the eutectic line, which, at 380° C. consists of a solid alpha solution with less than 1 per cent aluminum plus a solid beta solution of the combination Al_2Zn. At a lower temperature, 256° C., the beta solid solution breaks up into alpha and gamma crystals; the latter containing a greater amount of aluminum than the solid beta solution. An alloy with 8 per cent aluminum has, accordingly, at the ordinary temperature, a structure consisting of alpha and beta solid solutions close to their eutectic.

Remarkable is the segregation of the No. 7 alloy (see Table for its composition) which in the various specific weights are confirmed by the solid solutions alpha and gamma.

In addition to the above named alloys: zinc (99 per cent) was drawn into bars for the purpose of conversion into fuses. These were cut into pieces and at 100° to 130° C. were compressed into zinc fuses. The No. 1 alloy (see Table for its composition) should be the lowest in tin and copper; no antimony and the least amount of aluminum or none at all. They were merely an overload and the composition recommended at that time must be regarded merely as such. From a metallurgical standpoint the introduction of No. 3 alloy (see Table for its composition) was considered inadmissible. The ordinary commercial refined zinc, on an average, contains almost 1.3 per cent Pb. In addition to 1 per cent Pb. this would yield 2.3 per cent Pb. Since however the solution capacity of zinc for lead at the utmost amounts to 2.5 per cent and at the pouring temperature of the fuses—the content of tin of 2 per cent has no effect—the solubility at the maximum is put up to 1.5 per cent Pb., it must without further discussion form segregations at the cooling point of the fuses. This conclusion is also confirmed by the solubility curve of lead and zinc by Spring and Romanoff (P. Goerens. Introduction to Metallographie, p. 21). According to that data the lead-zinc alloys offer a notable example of metal solutions whose

*Translated from *Stahl und Eisen*, April 1 and 29, 1920.

solubility in the molten state is very fluctuating. While at 920° C. the miscibility of both metals is unlimited, but its capability of mixing declines with the lowering of the temperature. In the still homogeneous fluid mass there are formed, then, two layers: one rich in lead and one poor in lead. In freezing a further separation takes place.

The alloy No. 6, with zinc 98 per cent and iron 2 per cent, metallurgically has also been found not unobjectionable. If the iron is combined with the zinc up to about 5 per cent, then, even at 2 per cent, the zinc-iron alloy is extremely brittle and hard, even to the naked eye. With a somewhat higher percentage of iron, the fracture is conchoidal; furthermore such an alloy is but slightly stable. As a consequence these alloys could not be considered available for fuse castings. The alloys Nos. 4 and 5 (see Table for their composition) with 4 to 5 per cent aluminum have a decidedly coarse crystalline structure and for that reason are also objectionable. What appeared to be most conformable to the experience at that time is the one with a composition of 95 per cent Zn, 1 per cent Sn., and 4 per cent Al.

Justification for the use of this alloy is based chiefly on the large percentage of zinc with little or no tin or copper and as an additional recommendation a superior machining quality and hydraulic impermeability. Concerning tensile strength, analyses, etc., no specifications would be published apart from the hint that the fuses must not be brittle. (This is one of the German secret alloys whose solution capacity and metallographic characteristics they refused to reveal, because, no doubt they were utterly satisfactory and of a high order.) Since it was conjectured that the specified fuse alloys did not meet the highest claims to tensile strength, a suitable pressure investigation of the fuses of these alloys was undertaken, which called for a very special remodeling of the materials.

The fuses were preheated at various temperatures, and by this treatment, the former fine-grained mass was transformed into a radiated fibrous structure. In the bursting charge and cleavage test the fuses were extremely tough; nevertheless the alloy had the disadvantage that the material, particularly in the fuses, was transformed into layers or striae and separated into zones distinctly outlined from one another. This special phenomenon arises from the fact that the stamping or punching pressure itself is rectilinear until it is transmitted to the lower, small pivot. Since the stamping of the upper finished profile of the fuse possesses but little capacity for machining, the action gave to the form of the fuse an inner neutralized and sharply circumscribed cone, with a fine-grained structure so that the additional roll-shaped material piled up, as may be distinctly seen in the original test sample itself. Upon the basis of these results, the further proposed experiments were cut short, since a completely unobjectionable cast fuse by reason of its homogeneous composition and texture appeared to be better than a stamped or pressed fuse from the same alloy.

It was shown however that the requirements for the strength of the fuses with the various alloys which had been tried out, had not been reached. On this account, the production of the zinc fuses from the alloys mentioned along the whole line had to be interrupted and aluminum or brass fuses had to be resorted to in their stead according to the relative production in reserve of those metals. This reversion, in return, led to trouble in the foundries as also in the operations in the machine shops. Only stamped or pressed zinc fuses were permitted to be made from pressed zinc bars.

In the meantime further research work with zinc alloys had not remained idle. For this series of investigations there was chosen a zinc alloy that had been introduced into Austria long ago. Its composition was from 4 to 6 per cent Cu., 2 to 3.5 per cent Al., balance zinc. Of additional constituents the maximum permissible was 2 per cent. Therefore the lead could not be over 1.3 per cent, tin not over 0.5 per cent and iron not over 0.4 per cent. To this as a rule copper and aluminum were not to be below 7 per cent, nor more than 9 per cent. As a rule the alloy was worked with 5 per cent Cu. and 3 per cent Al., with the endeavor to hold the rest of the admixture as low as possible.

The structural formation exhibited numerous crystallites of the solid solution of copper. On the cast surface the crystal structure is distinctly visible. Generally the grain size increased as the copper diminished, which, by comparison with the alloys 33 and 37 (see Table for their composition) is recognized. The structural formation discloses bright crystal aggregates embedded in a dark matrix. Skeleton crystals of a solution poor in copper were visible as they were in alloy No. 31.

The behavior while in a molten state indicated the correct treatment for all of the above established points for castings completely free from all objections. The rupture charge, impact, bursting, cleavage tests, machining properties and impermeability were good.

One after another, now, the various changes in the zinc alloys were to be carried out. If also, by this means, the transient succession of the finished fuses was interrupted, then the interruption with a better prospect of success on account of the construction might still be put into operation. With a correct check on the transient succession the treatment of the alloy, here and there, must be interrupted by the interpolation of alterations of the aluminum alloys because the latter for the kinds of fuses previously decided upon must still be retained. The aluminum alloys are to be referred to later.

On account of the great scarcity of copper it was necessary to change the unobjectionable zinc alloy No. 31 (see Table for its composition). The first change made related to the lessening of the copper as well as the aluminum respectively. The alloy contained 3 per cent to 4 per cent Cu. and 0.5 per cent to 1.5 per cent Al. The structure of No. 35 alloy is very crystalline and dense. The light crystal aggregates appear to be few in number.

Besides, on account of the varied amounts of copper and aluminum the remaining determinations should hold good. Nevertheless it was immediately shown that this alloy was not so unobjectionable as the preceding one. The tenacity fell, although it always remained above the lowest specified limit. The correct check on the required pouring and chilling temperatures was of much greater importance than in that of the first alloy. Here, therefore, is a case, which by slight changes in the material of the alloy was at first perceptible in the velocity of the cooling. The size of the crystals and the structure and with them the hardness and tenacity depend upon slight temperature differences. (E. Preuss, Berlin, 1913—The Practical Application of the Testing of Iron by Etching Methods.) The alloy had to be abandoned. By increasing the copper and especially the aluminum an alloy of 4 per cent plus 0.5 per cent Cu. and 3 per cent plus 0.5 percent Al. was introduced. On account of the increase of the copper, and because of the doubling of the aluminum it showed a greater toughness, at the same time the permissible shrinkage was adjusted upward. The great lack of copper was forced afresh for consideration, in spite of the unfortunate experience which came to pass from a former effort to economize in copper. As a compensation for the reduction of copper a slight increase of aluminum was provided for.

An alloy, therefore, was obtained with 1.25 per cent Cu. and 3.75 per cent Al. With this alloy the tensile strength fell decidedly. The structure was coarsely crystalline and put forth phenomena that should be more closely examined. The structural formation of No. 37 (see Table for its composition) is similar to that of Nos. 35 and 39. Also here the structure is clearly visible on the surface of the casting. Shortly after the casting was poured the rupture charge gave a tenacity that was directly above the specified minimum limit. About three months later, in a remarkable manner, fractured fuses of the same alloy and from the same place gave an abnormally

Alloy No.	Zn. %	Sn. %	Al. %	Cu. %	Pb. %	Fe. %	Si. %	Mg. %	Pouring Temperature °C.	Chilling Temperature °C.	Tensile Strength Kg. per Sq. mm.	Tensile Strength lbs. per sq. in.	Remarks
1	95	1	4	....	....	....	....	....	510–530	210–230	8.3– 8.1	11805–11531	....
2	92	6	....	2	....	....	....	....	500–530	200–220	7.3– 7.6	10383–10810	....
3	97	2	....	....	1	....	....	....	....	....	....	....	....
4	96	....	4	....	....	....	....	....	....	....	....	....	....
5	95	....	5	....	....	....	....	....	500–530	200–225	10.7– 9.8	15219–13939	....
6	98	....	....	....	....	2	....	....	....	....	....	....	....
7	92	....	8	....	....	....	....	....	500–530	200–225	....	....	....
15–16	....	5.88	91.3	2.21	0.11	0.5	....	....	720–730	290–310	8.7– 9.8	12374–13939	....
17–18	28.66	....	70.11	trace	0.3	0.48	0.45	....	650–670	250–270	14.2–12.7	20197–18064	....
19–20	13.66	5.07	79.56	0.89	0.26	0.56	....	....	710–720	280–350	20 –18.1	28447–25744	....
21–22	93.7	1.21	3.87	0.33	0.89	trace	....	....	510–530	210–230	8.3– 8.1	11805–11531	Dull sound
23–24	91.74	5.35	....	2.02	0.65	0.24	....	....	500–530	200–220	7.3– 7.6	10383–10810	Dull sound
25–26	93.02	0.43	5.52	0.05	0.80	trace	....	....	500–530	200–225	10.7– 9.8	15219–13939	....
27	90.55	0.33	8.05	0.18	0.89	trace	....	....	500–530	200–225	....	....	....
31–32	90.90	0.13	3.15	5.25	0.57	trace	....	....	525–545	230–250	15.4–14.2	21904–20197	Clear ring
33–34	93.10	0.39	2.75	3.10	0.66	trace	....	....	510–530	220–240	11.6–12.9	16498–18348	Dull ring
35–36	94.24	0.12	0.88	3.67	1.09	trace	....	....	490–510	190–210	10.9–11.1	15504–15788	Dull ring
37–38	93.99	trace	3.83	1.32	0.86	trace	....	....	510–530	215–240	9.2–10.0	13086–14223	Dull ring
.....	.....	....	.....	....	....	.....	....	....	....	....	10.9– 8.2	15504–11633	Clear-Dull ring
39–40	93.75	0.12	3.25	1.89	0.99	trace	....	....	520–540	220–240	11.0–11.1	15646–15788	Dull ring
.....	.....	....	.....	....	....	.....	....	....	....	....	10.7–10.8	15219–15361	....
42–43	7.04	....	90.12	....	....	2.07	....	0.77	730–750	280–300	12.9–15.0	18348–21335	Thread sheared
44–45	12.50	....	84.78	....	....	1.68	....	1.04	720–740	270–290	16.7–15.7	24153–22330	....

TABLE OF THE COMPOSITION OF ALLOYS

low tenacity, one that fell far below the specified limit. To be sure the cleavage and bursting tests exhibited a satisfactory toughness, nevertheless, along with the separate bursting in the fuse bodies there appeared concentric fractures, which, without further discussion of them led to the conclusion that in the internal formation of the structure at the point of fracture there was recognized an additional fine-grained (almost amorphous) structure. Up to the central portion, forward, it almost immediately passed into a coarse crystalline core. Segregation phenomena were not chemically established, since accurate analyses of the marginal and middle zone yeiled no essential variations. The slight difference was wholly accounted for by the amount of copper present. Also with the rupture charge there appeared both a coarse and a fine formation distinctly observable. The raising of the pouring and chilling temperature limit, at least within the allowable experimental error, resulted in no considerable effect upon the tenacity. Merely an investigation, which however for practice in quantity manufacture did not come into question, in which the drop of the temperature between the chilled and the cast alloy was extraordinarily high (which was therefore the case with a very cold chill) yielded, in consequence of the rapid solidification, a higher resistance to rupture, but at the cost of the ductility; the bodies were brittle. Besides, with a greater rapidity of cooling the piping extended (as previously indicated) so deep into the piece that it was apt to become unusable.

On the whole it must be stated that the fuses from the new alloys do not meet the required demands as to machining capacity and tenacity or at any rate that they come too near to being practically unusable. The homogeneity and density of the metal left nothing to be desired. This phase it showed quite clearly, when the permissible shrinkage for the amount of copper specified was found to be lower than claimed. Thus the copper fell below 1.25 per cent. The tenacity value then fell significantly below the specified minimum.

In machining the fuses the new alloy immediately exhibited faults that earlier were unknown. In the sheathing of certain joints or in the countersinking operations of certain drill-holes, fractures originated or metal parts became detached by bursting. This brittleness of the metal was traced back to the formation of coarse crystal surfaces that have no connection with one another. (Irregular crystallization is always an indication of inhomogeneity and probable weakness.)

Since the results of the investigation were obtained as described, two new alloys were immediately specified with an increase of the copper and a decrease of the aluminum to 2.5 per cent Cu. and 3 per cent Al. or 2 per cent Cu. and 3 per cent Al.

The structure of No. 39 alloy (see Table for its composition) is coarsely crystallized corresponding to the reduced amount of copper. The margin displayed stem-like fractures that in the cleavage tests were distinctly visible. Also there appeared ruptures paralleling the edges of the fuses on account of the slight cohesion of the separate crystals of the marginal zone with those of the central cores. The structural formation displayed light and dark crystals that were partly aluminum-rich and partly copper-rich.

Furthermore, these alloys did not turn out especially well, because of the so-called "Aging of Metals" arising after monthly changes in the structure of the fuses. In the metallographic investigations (undertaken at the fire works laboratory at Spandau) it was found that in the separate crystals of the alloy, in the course of time, parallel rents or fissures appeared.

By this means the tenacity of the fuses was lowered considerably. This is an interesting evidence of the so-called life phenomena or internal growth or change of inorganic materials. (A great deal of information exists in the literature, but is not brought together in a tangible shape for reference, concerning the effect of aging upon many zinc-aluminum alloys. It is not to be wondered at that the general director, Albert Wuerth, should designate such changes or growth as a remarkable phenomenon, because at the time it was a new development and but little known. The writer calls to mind an instance of the same character, and occurring during the recent war, in which a small propeller-shaped wheel, with four blades, used for stirring purposes in the chemical laboratory, supposed to be immune to organic acids, or sulphuric acid, appeared to be sound and homogeneous at the time of casting, but three months later, disintegration had set in, marked by crumbling at the edges, and fissures like season cracks made their appearance at the junctions of the blades with the central stem. The changes occurred so rapidly after having started that the use of that zinc-aluminum alloy had to be abandoned for that purpose. It had a composition of about 15 per cent zinc and 85 per cent of aluminum.)

In this case, as Czochralski says, in consequence of the internal condition of the alloy, there occur transformations of the structural constituents within the body without an external irregular treatment of the castings, whether this be

through the addition of heat or other factors, such as pressure, concussion, etc. With this internal variation of enclosing formations that occur, a force must be exerted that is very great, as in that one case immediate crystals were broken. In the metallographic laboratories of the Brothers Körting A. G. in Körtingsdorf in Hannover-Linden, it has been the intention to investigate bodies of that kind later, at repeated intervals of three months, in order to note whether there is any evidence of a further life or continuing growth in metal bodies that would lead to a continuous development or even to the ultimate destruction of the bodies.

That some days after the casting complete changes occur in the interior structure is known. On this account the castings must not be disturbed until the greatest of changes (self-hardening) has taken place.

Official attention was paid, quite particularly, to the tin-free aluminum alloys to be mentioned later, with additions of magnesium. (J. Czochralski—The life duration of *Metals-Giesserei-Zeitung* [Berlin], Jan. 1, 1915, p. 1)

It is still cited that at times many separate zinc fuses were replaced by iron fuses that were struck up in a die or made of cast-iron. Such fuses, or the greater part of them that were easy to finish, were made of cast-iron, and for parts unsuitable to be made of cast-iron, cylindrical pieces of zinc were stamped or pressed in such a way that they became an integral part of the fuse.

For the aluminum fuses the following alloy was specified: Cu. 1.5 to 3 per cent; Sn. maximum, 3 to 6 per cent; Fe. maximum, 1 per cent; Sn. maximum, 2.5 per cent; not less than 90 per cent. Another alloy consisted of 95 per cent Al., 3 per cent Sn. and 2 per cent Cu. The question of the scarcity of tin was always pressing. On this account the experiments with 10,000 fuses of various alloys were suggested:

1. 4.5 per cent Cu.; 0.5 to 0.75 per cent Pb., remainder aluminum.
2. 8 to 10 per cent zinc, remainder aluminum.

In workable properties both alloys were unserviceable, because all the shops were rapidly exhausted by the hardness of the combinations and the ensuing dullness of their cutting tools. On this account an alloy containing but little tin was specified:

Cu. 2 to 3 per cent; Sn. 2.5 to 3.5 per cent; Zn. maximum, 2.5 per cent; Fe. maximum, 1.5 per cent; Si. 1.0 per cent.

In the meantime the investigations were continued, in order to obtain an alloy free from tin.

Among the light metals was found magnesium, a metal that added to other metals, to some degree, unhesitatingly gave a possibility of applying such an alloy to the manufacture of fuses. The investigation of the action of magnesium was arranged for with three aluminum alloys consisting of 6 to 8 per cent Zn.; 7 to 9 per cent Zn. and 8 to 10 per cent Zn. with additions of anywhere from 0.5 to 1 per cent Mg.; copper not necessary to be present.

The structural formation of No. 42 (see Table for its composition) exhibited the same formation as No. 44. The gamma solid solution appeared to predominate. The alloy had the slight crystalline structure that is prevalent with aluminum alloys. The slight amount of magnesium exerts a marked influence upon the crystalline formation which by comparison with alloys free from magnesium is distinctly developed in them. As chief structural constituents alpha and gamma phases occur in solid solutions the same as was considered in the preceding alloy. By means of these alloys the efficiency of the machine shops dropped to about 30 per cent.

Further investigation was carried out with an alloy called "Electron," consisting of about 95 per cent Mg. and 5 per cent Zn.

For confirmation of the stability that the old tin-rich alloy had provided, a tin-poor alloy was introduced of the following composition:

Zn., 2 to 6 per cent; Sn., 1 to 2.5 per cent; Cu., 1 to 3 per cent; Fe., maximum, 1.5 per cent.; Si., maximum, 1.05 per cent; Mg., 0.02 per cent.

In the fuse alloy the permissible shrinkage was somewhat exceeded, the zinc limit was afterwards raised from 12 to 15 per cent and lowered below 6 per cent. The magnesium remained at 1 per cent. (The author does not state what success they had with the introduction of magnesium, nor what had been their experience with electron.)

CAST-IRON IN THE LAST YEARS OF THE WAR

In the preceding section the use of cast-iron was frequently mentioned as a substitute for various metals, of which there was a scarcity, to be used in motors, steam-jet apparatus, heating construction and the finishing of fuses. In the last years of the war, to the largest extent, the use of cast-iron was a peremptory necessity.

Various articles that have been mentioned and that had formerly been made of bronze or other non-ferrous alloys, now had to be made of malleable iron castings, or steel castings, or normal iron castings, and they had to be carried out for the most part with diminished weights and often be reconstructed. The lack of good pig iron, and the poor quality of the coke in the latter part of the war led to many dissensions which made the introduction of cast-iron very difficult to carry out, not only with the means of execution provided for it earlier, but generally because the poor quality of the iron produced slowed up the productive capacity of the foundries.

The poor quality of the cast-iron was caused:

1. By the inferior coke. In peace times the sulphur in the coke amounted to from 0.8 to 1 per cent at the most; during the war the sulphur rose to double that amount, with an average of 1.5 to 1.8 per cent. Furthermore the percentage of ash was abnormally high and hence the strength and the density of the coke were much deteriorated. The latter phase caused inferior cupola practice.
2. By the scarcity of pig iron. The scarcity of iron induced in addition a great quantity of breakage, spoiled work, etc. Alloying with 80 per cent of the breakage was arranged for daily, which in part resulted in dire consequences.

By reason of the circumstances described the spoiled castings, both in the foundry and in the machine shops increased daily in contrast to what occurred during times of peace. The castings were hard, frequently as a result of edge and surface hardening or because they were hard through and through, they were chiefly unworkable or machinable only with great difficulty. Since the machine shops could not get any more good tools the continuance of the finishing proceeded with many obstacles. On top of this, other troubles cropped out such as contraction fissures so that the breakage of castings during transportation or in cleaning the sand from them, and later in the formation of piping and blisters—all appeared to be on the increase. In the pressure tests the castings developed soft spots and also broke differently.

An earlier, less known phenomenon appeared for a time, namely, the numerous so-called "reversible chill castings." The walls of the castings were hard and white within, therefore without graphite formations and, in addition, gray, therefore, normally graphitic iron. The analysis of both formations from various spots to discover the form of the carbon present gave the same chemical composition; also the total carbon was in agreement. The literature on the subject is as follows: (B. Osann, *Gies.-Zeit.*, Feb. 1, 1918, p. 33; P. K. Nielsen, *Gies.-Zeit.*, Oct. 1, 1918, pp. 299-305; Adammer, *Gies.-Zeit.*, Nov. 15, 1918, p. 385; Tech. Abteilung des Giesserei verbandes., *Gies-Zeit.*, Dec. 15, 1918, pp. 381-382; Pfalzgraf, *Gies-Zeit.*, Feb. 15, 1919, pp. 56-59; Harnecker. *St. u. E.*, Oct. 30, 1919, pp. 1307-1308.)

By means of a special method the reversible chill castings were frequently ingeniously reproduced. For the supervision of the tapping each cupola, from time to time, cast wedge-shape pieces 22 by 105 by 125 millimeters in extent. From the structure of the wedges and the view of the surface

fracture, according to the nature and extent of the hardness, the quality of the heat could be ascertained.

This sharp and practical supervision of the operations in the last years of the war was absolutely necessary. Soon after the test wedge was cast it was seized by tongs, and as soon as it was cool enough it was plunged into water and broken by blows so that the edge hardening could be inspected. Then first, the specimen from the cupola was compared with the piece obtained from the corresponding casting. It often happened that the center part of the wedge was still in a fluid state. By means of quenching in water the core remained white while the marginal edges became gray. (In the original text illustrations are given of the test pieces, but the imprint is so indistinct that the differences in the surface structure cannot be detected by inspection.)

In part the reversible chill was avoided by careful selection of the fragments, by adding manganese pig iron containing from 4 to 6 per cent Mn., by the use of the best quality of selected coke and by drying the coke in an oven to expel the moisture absorbed from the air or by exposure to bad weather.

In the course of the difficulties described previously, upon metallurgical grounds, many phenomena plainly appear that from the generality of this or that occurrence were not wholly or but little known, and their proper evaluation developed under the pressure of the exigencies of the war.

(In but two places in the text is the scarcity of aluminum referred to. As a vast amount of aluminum was consumed in the manufacture of dirigibles and airplanes, it may be that the requirements of that branch of the military service made it difficult for the foundries to secure the amount of aluminum desired for fuse construction. Although the well-known light metal "Duralumin" was used all through the war in the construction of parts of dirigibles and airplanes, nowhere is it mentioned in the text as being used for the making of fuses. In 1910 the metallurgists of Germany were better acquainted with duralumin, its manufacture, its physical properties, the methods to be pursued in its heat-treatment, and the effect upon it of aging, than anybody in this country until nearly the close of the war when American metallurgists had completed their investigations of it and had learned about its invaluable properties and the proper methods to pursue to develop them. It certainly leads up to a puzzling commentary on their repeatedly asserted super-man power and adaptability to have overlooked the possibility of using duralumin as a substitute for bronze in ever so many articles they required and so successfully carried out to continue the war.)

SUMMARY

For the construction of Diesel engines, centrifugal pumps, as well as for valves and cocks it happened with the substitutes used for the saving of metals that the results remained the same. On the other hand the durability of the metals substituted for steel in apparatus originally built of steel has not been confirmed. In the manufacture of projectile fuses the substitutes used were accompanied by far-reaching results. The possibilities of these substitutes were specified to the very limit and the kind and manner of the difficulties that were met with were overcome.

(The measures taken, the expedients resorted to, the profound knowledge of the physical properties of the useful metals exhibited and applied, offer a spectacle to the closest observers of what almost super-human skill and untiring endeavor could and did accomplish, for which there is no parallel in history.)

FERRO CERIUM

This interesting alloy was discussed by A. Hirsch before the American Electrochemical Society, being his second appearance on that subject before that group following the presentation nine years ago when pyrophoric alloys were more or less of a curiosity. Today ferro cerium is decidedly an item of commerce, and in Europe more than in America is replacing the match as a more convenient and safe method of lighting. The ferro cerium lighter has been nicknamed the iron match and is non-poisonous, is more compact, and where shipments are concerned has an advantage in that the ordinary match occupies a large space in comparison to its weight.

The cerium alloy manufacture derives its raw material from by-products of the gas mantle industry. The first step in the manufacture of ferro cerium is the preparation of the electrolite which is a difficult matter in view of the fifteen or twenty elements which may be contained in the raw material. The mixed chloride used as the electrolite must be freed from all substances which will interfere with the electrolysis, including sulphur, phosphorus, and silicon. There are many factors which must be kept in proper relation each to the other, and the electrolysis involved is indeed complex and difficult. The cerium in reality is an alloy of the metals in the cerium group and the electrolysis is not selective, but the cerium group appear to form an aggregate or nucleus. The alloy is soft and tough, can be cast into molds, can be cut with a strong knife, and is not pyrophoric. In many respects it is similar to lead. The cerium alloy is now melted and alloyed with iron to form a product about 30 per cent of iron, and this alloy is pyrophoric. Other special mixtures give a flame or a shower of sparks or some other similar reaction as desired, and involve the use of magnesium and zinc. Thus for miner's lamps a flame instead of a spark is desired.

The pyrophoric property would seem to depend upon the brittleness of the alloy and its low kindling point, the cerium group being exceedingly active and having a great affinity for oxygen and nitrogen. These same properties make the cerium alloy previous to its combination with iron a satisfactory deoxidizer of molten metals. With cast iron where this material had been used the castings were softer and more dense, and the formation of fine carbon was retarded. The resulting castings were sound and machined satisfactorily. Even when one-half of one per cent of cerium had been used none could be found with the finished castings, giving rise to the belief that any cerium not required as a deoxidizer is probably oxidized by contact with the air over the ladle.

The pyrophoric alloys are well established in their particular field and may become equally well known as metal scavengers.

CAUSES OF DISCOLORATION OF LIMESTONE

The discoloration of limestone used in construction work is a serious matter and very often mars the appearance of new buildings in a comparatively short time. Leaching tests to determine the cause of this discoloration have been carried out and as a result of the work it appears that the unsightly brown stains are not due to the iron content of the cement which was previously supposed to be the probable cause of this trouble. Cement with a very high percentage of iron has produced no stain, while other cements with a small percentage of iron have given intense stains. No stains have appeared in the tests of lime mortar or slag cement. The stains, however, can be reproduced to a marked extent by allowing a solution of sodium hydroxide to leach through the limestone which indicates that the soluble alkalis in the cement are responsible for the formation of the stains.

COLORED PLASTERS

Many decorators and artists have wrestled with the problem of securing wall plasters of desired color and texture for given purposes. The Bureau of Standards Technical News Bulletin, No. 41, reports the results of investigations which indicate that wall plaster of any desired color or texture may be made by using dyed wood fiber in the gypsum plaster. Various mixtures of colored fibers are, of course, possible and panels of the material have been submitted for further tests to the Gypsum Industries' Association. A publication on the subject is now in course of preparation.

Mineral Wax*

The Importance of Ozocerite As a Lubricant

By H. Pomeranz

THE names "machine grease" and "wagon grease" are given to the type of lubricant which is made from thickened mineral or tar oils, having the consistency of dough or a soft fat. The fast fat or hydrocarbon (paraffine cerasin) or, what is still more frequent, the free soap in the mixture is dissolved in the liquid mineral oil to form a thick solution which becomes thinly liquid at elevated temperatures and congeals on cooling to a solid mass.

During the war, the deficiency in the supply of saponifiable fats and solid hydrocarbons caused the manufacturers of lubricating greases to look for substitutes and their attention was drawn at once to ozocerite[1] which had been used hitherto for making shoe polishes. Ozocerite can be saponified to form a solid soap, which, when dissolved in petroleum in the proportion of 1 to 7 or 1 to 8, makes a solid mixture, which begins to flow at about 80° C. It is of course obvious that the real lubricant is the oil itself. The purpose of the soap, dissolved therein, is to make a composition of higher melting point, so that the liquid oil is prevented from dripping down from the bearings and going to waste, due to the friction and heating of the surfaces that are being lubricated. Hence, ozocerite does not play the part of a lubricant in the compounded grease. It is only necessary to take care that the ozocerite does not detract from the lubricating properties of the oil. Both the quality of the mineral wax and the nature and method of making the soap are the determinate factors in this respect.

The chemical properties are well-known and fully described in the literature. They need no mention here.

In the technical processing of ozocerite, there are a number of important points which require the attention of the technologist. In the first place, in determining the saponification number of the wax by means of alcoholic potash, it is observed that there is a considerable quantity of unsaponifiable residue. The saponification number is between 90 and 100. It is uncertain whether or not all, that is saponifiable, is saponified at the boiling point of the alcohol, or whether a greater proportion of the wax is converted into the soap, when saponification is accomplished by treating the melted wax at a temperature of 130° C. with an aqueous solution of the alkali.

Furthermore, if melted ozocerite is treated with concentrated alkali, a hard mass is obtained, which is difficultly soluble in mineral oil. For this reason a mixture of ozocerite wax and mineral oil is generally saponified. It is certain that the saponification is much more difficult to carry out than with pure mineral wax.

*Abstracted and translated for *Scientific American Monthly* from *Kunstoffe*, 1920, 85-86.

[1]Ozocerite is a naturally occurring solid hydrocarbon of the olefine series. It is found chiefly in the Galician oil fields, where it occurs in veins at varying depths below the surface up to 250 yards. The wax is also mined in Roumania. In this country the main deposits are located in the Wasatch Mountains, about 173 miles east of Salt Lake City, Utah. The American deposits are said to be miles in length and contain a white ozocerite. The wax is also found in Colorado. The main use for ozocerite is in making ceresin. The mineral wax is subjected to a steam distillation and the distilled ceresin is compressed by hydraulic presses, melted and then treated with fuming sulfuric acid. Good ceresin can hardly be detected from bees-wax.

Ozocerite is used in the manufacture of candles, ointments, pomades and shoe blackings. It is also used to some extent in the manufacture of shining black paper and for the impregnation of certain kinds of wood in furniture manufacture.

Okonite is the residue left after the distillation of ozocerite. It forms an excellent insulating material for electrical purposes.

The use of ozocerite for lubricating purposes is a new use of this material. The properties of the wax would tend to make it appear as if considerable success could be obtained with it in this way.

The appearance of a lubricant is an important property and the dark brown color of the ozocerite lubricant is a disadvantage. The color is due to certain dark products contained in the wax. Bleached ozocerite is a light brown material, which, however, does not give a light-colored lubricant. On the other hand, the refined wax is capable of being saponified completely. In this manner a transparent lubricant is obtained. The lubricating properties are also improved to a considerable extent.

It is very difficult to determine just how much free alkali there is present in a lubricant, made from mineral wax and oil. The ash always contains carbonate. A solution of ozocerite soap in water gives no light-colored precipitate with mercuric chloride. The more lye is used to saponify the wax, the harder the lubricant becomes. The poorly advised technologist does not pay any attention to the "lye" content of his "fat" as a general rule. He is concerned entirely with obtaining a proper consistency in his product. It is important to take particular care that too much lye is not used.

It is a question whether or not the solution of ozocerite soap in mineral oil leaves any injurious or troublesome deposits on the metal. This can only be observed by actual practical tests. The chemist has been thoroughly convinced that the use of mineral wax in a solution of mineral oil for lubricating purposes possesses very great advantages. The user of the compounded grease should not be prejudiced by its dark color which does not mean in any way that it is of an inferior quality.

A JAPANESE DISCOVERY TO FACILITATE THE HARDENING OF OILS

ONE of the most valuable discoveries in the realm of industry in recent years is that of the process for hardening liquid oils. This has various applications particularly in the manufacture of "butterless butters." One of the most useful agents in producing this hardening is the seed of the castor oil plant. However, this has the disadvantage of not keeping very well. It is of interest, therefore, to learn that a Japanese investigator, Mr. Yoshio Yanaki, has invented a method of extracting the active principle of the castor bean. This extract he terms lipase, and after extended experiment he has made public the following conclusions in regard to its action:

1. It is shown that lipase acts with less rapidity upon oxidized oil, prepared by insolation or by blowing air, than the raw oil. This reduction of the activity of lipase on oxidized oil is most marked in the case of drying oil, and it decreases through the classes of semi-drying and non-drying oils.

2. The slowness of the lipolysis of oxidized oil is due to the presence of some oxygen-absorbed products which are decomposable by lipase with less rapidity and which have probably a larger molecular weight owing to the absorption of oxygen.

3. The lipolysis of rancid oil is also slow, possibly on account of the presence of the oxidized products named, and of aldehydic substances, the latter injuring the activity of the lipase.

4. An oil exposed to sunlight, while protected from contact with the air, does not show any retardation of its lipolytic hydrolysis, showing that light alone produces no effect on the chemical composition of oil.

5. Heated oil which has been prepared by heating in a current of nitrogen, is more difficult of hydrolysis by lipase than the raw oil, showing that the polymerized products of glycerides are with difficulty decomposable by the enzyme.

IN THE HEART OF A POTASH MINE AT STASSFURT 2,600 FEET UNDERGROUND WHERE TEMPERATURE IS 104 DEGREES F.

German Potash Mines

The Possibility of Finding Potash Deposits in This Country

By Robert G. Skerrett

POTASH in the decades gone, when soft soap was a common commodity in the household and not the synonym for conversational blandishments, was generally got from wood ashes subjected to a simple leaching process. The very term potash is a word picture of the way in which the alkaline liquor was boiled down and concentrated. At that period in our development, potash so obtained served as an essential ingredient not only in the preparation of a laundering aid, but it figured in the manufacture of glass, powder, etc. Farmers knew that their crops were likely to be more abundant if they burned over the dry vegetation of their fields or scattered wood ashes broadcast upon their acres; but only a few husbandmen were aware that a measure of potash was indispensable to their crops and needed proportionately more by some than by others.

Potash, or potassium as it is technically named, has assumed a position of prime importance in the economy of modern life far beyond that imagined half a century ago. Not only is the stuff required in the making of glass, as a source of nitrate in the explosive industry, and as a base for cyanide so widely employed in metallurgical activities, but the sulphate and the chloride of potassium are outstanding factors in the manufacture of so-called artificial fertilizers. Finally, to a lesser degree, but likewise invaluably, potassium salts are used in dyeing, tanning, electroplating, photography, medicine and as chemical reagents for a variety of purposes.

Just what potash means to us can be gathered from the fact that up to the outbreak of the World War we imported from Germany our principal foreign source of supply, substantially a million gross tons of the salts each twelve months; and probably about 90 per cent of that material was devoted to the enriching of our cultivated soil. There are three plant foods of outstanding significance—phosphorus, nitrogen, and potassium, and the last serves to promote stalk strength and a more generous kernel filling in a growing plant. Fields denied a sufficient quantity of potash yield crops of an impaired and sometimes an unmarketable character; and the best proof of this is what happened in our farming districts when cheap potash from the mines in Prussian Saxony was cut off from us by reason of the conflict in Europe.

According to testimony given before a Congressional committee in 1919, the lack of potash had a serious effect upon our cotton, potatoes, onions, citrus fruit, and garden truck, and this largely because the commodities were deficient in that strength needful to enable them to withstand transportation and to keep them fit until sold. As one prominent farmer from the South explained it, "If there is not enough potash in the soil, I get a plant that is so sappy and tender that it won't bear transportation. And to get that plant sufficiently woody and strong to bear a long trip we have to use from 10 to 14 units of potash per acre." A unit is 20 pounds of pure potassium oxide. Time and again, peaches, strawberries, cabbages, beans, cucumbers, etc., which appeared all right when picked, would spoil or fall below standard by the time they reached a far-off city, and that in spite of refrigeration en route. Ground that would ordinarily give a crop of 80 barrels of potatoes to the acre would yield only 11 barrels and even then the tubers were not up to the usual size.

With cabbages, potatoes, and onions constituting the principal vegetable items of the dietary of the vast majority of our people, and with cotton forming the fiber for that textile used in such vast quantities by both the rich and poor of the nation, it is not hard to visualize how vital to our well-being is an abundance of low-priced potash. When the German potash deposits were first exploited sixty-odd years ago, and the mining of those beds proved a simple and fairly inexpensive operation, the agricultural world breathed freer; for the geologists proclaimed that there was enough of the alkali tucked

away there under ground to meet the demands at home and abroad for centuries to come.

These mines are located near Stassfurt, and were discovered by the Prussian Government in 1843 while boring for rock salt. For some years no attention was paid to the potash, which was brought up to the surface and cast aside. But afterwards, when it was found that potash was essential to the stimulation of crop production, the value of the neglected piles of mine waste dawned upon the Teutons; and out of that awakening developed the well-known Kali Syndikat which became all-powerful in the international distribution of those potassium salts. This was made possible by the fact that the Germans could mine, ship across the ocean, and deliver the potash at the ports of our Atlantic seaboard at an average price of from seventy to eighty cents per unit of pure potassium.

The Stassfurt salt beds, with their interposed layers of potash, were deposited there in the Quaternary Age of this globe of ours, when the present plains of northern Germany lay deep beneath a briny ocean. In the course of time, using the term in the ampler geological sense, the potash separated from the salt and was precipitated in the form of strata or pockets. This process has a great deal of significance to us in view of the fact that vast deposits of salt, likewise the relics of a sea that evaporated eons back, lie far below the ground level in a widespread area extending north and south throughout certain of our Central States. A similar condition probably exists elsewhere upon this continent of ours; but the revelations in question have been made by borings driven in search of petroleum.

In 1914, prior to hostilities, the German potash industry at Stassfurt was centered about 187 shafts, and the operating force numbered 35,000 people. It is said that quite $250,000,000 has been spent in developing the properties, and that the mines are capitalized at substantially $380,000,000. An official of the U. S. Bureau of Mines has lately visited the region and has reported that the "Stassfurt potash occurs as potassium chloride or potassium sulphate or both salts intimately mixed with salts of sodium, magnesium and lime, and contaminated with substances insoluble in water, such as ferric oxide, clay, etc. The potash salts are segregated in more or less extensive pockets throughout the salt mass. . . . The main potash region is a stratum varying from 30 to 150 feet in thickness and at a depth requiring shafts of 5,000 feet." It should be evident that the raw product is of a mixed nature, and when sold as such is valued according to the percentage or number of units of pure potassium which the stuff contains. On an average this is in the neighborhood of about twelve per cent of pure potassium.

According to the German laws, each mine must have at least two shafts—one for ventilation and one for active operation. These shafts are placed from 500 to 1,000 feet apart and are connected underground. This arrangement insures that the air drawn down one shaft shall, after circulating through the several mine passages, ascend by the other shaft and thus carry off the vitiated atmosphere. The duplication of shafts further provides a means of escape for the workmen in case one of the shafts is closed by accident. It is the practice to line the shafts from top to bottom with iron, concrete or wood, according to the local needs and the availability of the materials mentioned. The shafts average about 16 feet in diameter.

As might be expected, water reaches the shafts by reason of seepage working through at the upper levels. This water drains down into sumps at the foot of the shafts, whence it is forced surfaceward by pumps. The mines are otherwise dry. Because inflammable gases appear only infrequently, the miners work by the light of bare flames, using generally a rather common type of acetylene lamp. The danger of unexpected gassing is neutralized by the action of blowers, which are kept running close to the points where the men are at work. The potash is blasted out at the face of the headings and freed in this manner in big masses. The needful holes for the explosive charges are made with electric drills and augers. The material is then broken up by the miners into good-sized lumps—using picks and heavy hammers for the purpose. At the same time the laborers separate the low-grade material from that of commercial value, and the rejected stuff is used, as occasion requires, to fill up abandoned workings.

The potash is transported from the headings by electrically-drawn trains made up of small iron cars or "buggies," and moved by rail to the elevators located in the shafts. These lifts are functioned by a mechanical contrivance that insures a nice control of their speed. There are two counter-balancing elevators in a shaft, and this interrelation has much to do with the safety of their service. Each lift is a double-deck structure which can accommodate from six to eight of the mine cars; and when working to capacity it is practicable to send to the surface between 800 to 1,000 tons of the raw potash daily by way of a single shaft.

Upon arriving above ground, the buggies, with their burdens, are run upon a platform where they are caught and held while being tipped over to effect discharge, and the crude salt drops by way of a chute into a power-driven crusher located below. From the crusher the substance may be dealt with in two ways, *i.e.*, it may be ground into bits, having a maximum dimension of a quarter of an inch, and then removed to storage awaiting shipment, or the granular material may be sent to a refinery, frequently near by. Here, trained oper-

LOADING AN ELEVATOR AT THE BOTTOM OF A SHAFT 2,500 FEET BELOW THE SURFACE

A TRAIN OF CARS OR BUGGIES LOADED WITH POTASH DRAWN BY AN ELECTRIC LOCOMOTIVE

atives sort out further the relatively high- from the low-grade potash. The latter is passed on to a grinding mill where it is mixed with raw salts, and the better grade is carried to another grinding mill and from it dropped into an elevator that transports it to the storage bin preliminary to undergoing additional treatment.

According to the report of the representative of the U. S. Bureau of Mines, who visited the European mines, analyses showed a raw salt averaging 15.6 per cent potassium oxide, while the rejected or low-grade material contained 5.8 per cent K_2O. As he explains: "The latter being added to the raw

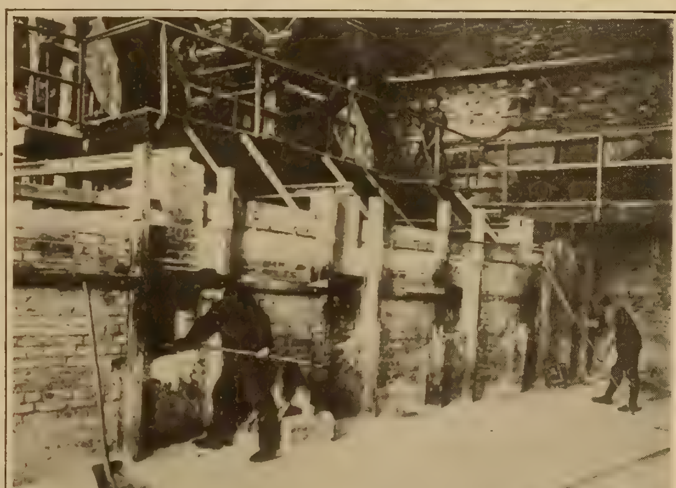
LUNCH TIME IN THE POTASH MINE

salt or 'stock kainite' brought its potash content down to 14.3 per cent, while the rich salt for the refinery was brought up to 18.6 per cent K_2O." The procedure in the refinery rests on the fact that if a solid mixture of the chlorides of potassium and sodium be brought in contact with a saturated solution of the same salts, and the combination be then heated, this treatment will induce the precipitation of a greater amount of solid sodium chloride and effect the while a further solution of a considerable percentage of potassium chloride. By properly handling thereafter the masses of brine and solid salt it is feasible to accomplish the complete recovery of the potassium chloride in any desired degree of purity.

The actual working of the process commercially is as follows, according to the authority just cited: The rich salt, so called, is fed into one end of a trough, made of sheet iron, and the boiling-hot brine enters at the other. The trough is fitted with a screw device which thoroughly stirs the mass and gradually drives the solid contents toward the opposite end of the trough and against the on-coming flow of the liquid. The trough is equipped with steam pipes which enable the temperature of the mixture to be raised as high as 230 degrees Fahrenheit. The solids in the trough or dissolver are removed by a screw-like elevator, washed, drained, and piled, until sufficiently air dried, when they are either returned to the mine to fill abandoned passages or are sold for crude sodium chloride. The washings are added to the mother liquor and used for subsequent dissolving operations. The hot brine from the trough is led to settling tanks, where the temperature falls slightly below the boiling point, and the somewhat clarified liquor is thence siphoned to the crystallizers. The residue in the settling tanks is drawn off, and drained more or less imperfectly, and the drippings are added to the mother liquor—the solids, for the most part clay, being discarded. The residue, amounting to from 6 to 8 per cent of the product as it comes from the mines, carries probably 1.5 per cent of potash. It seems that the loss of potash in the residue is but little more than 1/10 of 1 per cent.

Crystallizers are nothing more pretentious than flat iron boxes about 2 feet deep and large enough to hold approximately 6,000 gallons of the brine solution. Three days are commonly required to bring the temperature down to 50 degrees Fahrenheit. Each "pan" will yield better than 3 tons of crystallized potassium chloride; and a plant equipped with 72 crystallizers, working in three groups of 24 units, will turn out an average of 80 tons of finished salt every twenty-four hours. The mother liquor is used over and over again. The Germans have done this for 12 months' running—discarding the liquid only when it became too highly charged with magnesia and other impurities to make it serviceable. For a plant of 72 crystallizers, the coal burned, exclusive of that for the generation of electric current, has been at the rate of 13 tons per day in the refinery, and probably about 7 tons additional for general purposes in the mine, the plant, and office.

The potash deposits in Alsace, which are now in the hands of France, were only moderately exploited by the Germans prior to the World War, and they were tapped by but 17 shafts. The beds were discovered six miles northwest of Mulhouse, as recently as 1904, during exploratory borings for oil. The first mining shaft was completed in 1909 and production started in 1910. In 1913, 40,707 tons of K_2O was procured from that source. The Alsatian deposits differ notably in physical and chemical characteristics from those in Saxony. The lower layer lies at an average depth of but 1,800 feet, and constitutes a fairly continuous stratum, composed of a mixture of potassium and sodium chloride, extending over an area of upward of 77 square miles and having a mean thickness close to 11.5 feet. Twenty feet above this layer is a parallel but less extensive bed, ranging 4 feet through. Both beds are pretty commonly banded with blankets of clay, and these vary in thickness from a fraction of an inch to several inches. The upper deposit is deemed less important, and is looked upon as a reserve which can be worked later on. The volume of the two layers is estimated to be 1,350,000,000 cubic yards calculated to contain in the neighborhood of 1,500,000,000 tons



CALCINING OVENS IN WHICH THE POTASH SALTS ARE THOROUGHLY DRIED OUT

of salt or 275,000,000 tons of pure oxide of potassium—enough to meet the world's demands for possibly two centuries. The Stassfurt beds, on the other hand, are said to contain fully 2,000,000,000 metric tons of K_2O—sufficient to meet man's requirements for 2,000 years at the normal rate of consumption.

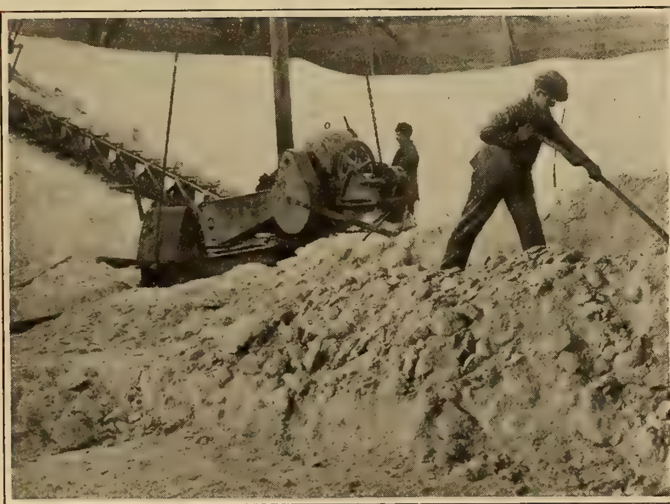
The World War brought America face to face with the possibilities of a grave potash shortage. The year before the outbreak of hostilities our importers were paying less than $90 a ton for pure potassium oxide, and before the close of 1917 domestic potash, at the plants of fertilizer manufacturers, was fetching $560 a long ton! This was derived from original sources such as alunite, the brine of certain of our highly alkaline lakes in some parts of the country, kelp, and as a by-

product of the cement industry, from wood ashes, molasses distillery waste, beet sugar refineries, etc.

By dint of very commendable enterprise and outlays totalling, so it is authoritatively declared, substantially $40,000,000, patriotic citizens embarked upon the upbuilding of a domestic potash industry. The natural salts or brines from Searles Lake, California, and the lakes in northwestern Nebraska were the principal origin of the much-desired potash obtained here after we were thrown back upon our own resources. In 1918, it was from Nebraska that we secured approximately 60 per cent of the potash produced within our borders. The section is known as the sand-hill district of Nebraska, where foliage is commonly lacking, although the soil in the valleys is fairly well cloaked with a growth of grass.

Within that region lie, in round numbers, 3,000 lakes ranging in size from modest ponds to bodies having an expanse oı 600 acres. The depths of these waters run from 1 to 6 feet, and virtually 10 per cent of them are decidedly alkaline, and fully 150 of these ponds and lakes carry a high percentage of potash. The richest brines are in the bed mud and sands, and these extend downward for from 15 to 40 feet. The brines are readily obtained by pumping operations. The productive area beneath the several lakes differs greatly. That is to say, it has been found to underlie a large part of some lakes and yet, as a rule, only a small proportion of the subsurface sands have yielded brines in commercial quantities.

A very significant feature in connection with these Nebraskan fields has been the results realized from a few wells sunk in valleys more or less distant from the lakes. The quality of the brines brought to the surface have suggested that the productive region may possibly reach far beyond the lakes themselves and may even exist in localities where there are no lakes at all. Nineteen companies have operated in Nebraska, and during their activities developed capacities ranging from 3 to 200 short tons of crude potash salts daily. Inasmuch as the total quantity of potassium in these beds is rather speculative, their potential value cannot be determined. However, one investigator has put the recoverable underground supply at 100,000 tons of K_2O.



MECHANICAL CONVEYOR LOADING FREIGHT CARS WITH POTASH AT STASSFURT

From Searles Lake, California, we secured the second largest output of domestic potash, viewed as a single source, in 1918. The production was nearly double that of the year before; and the salts contained from 60 to 70 per cent of potassium chloride and about 15 per cent of borax. In the process of manufacture, after recourse to partial evaporation to remove a part of the associated salts, the brine is drawn off and allowed to cool—this procedure serving to precipitate the marketable potash. Estimates seem to indicate that Searles Lake contains the equivalent of 20,000,000 tons of actual potash in a saturated brine associated with soda, borax, salt, and sodium sulphate. The proportion of potash in the dried salts is about 7.2 per cent. In the German and Alsatian deposits the K_2O content ranges from 12 to 20 per cent.

Potash obtained from alunite in 1918 amounted to 6,180 short tons, containing 2,621 tons of potassium oxide, then valued at $1,276,774 at the point of shipment, *i.e.*, $4.87 per unit of K_2O. The entire output was derived from the alunite deposits in the vicinity of Marysville, Utah. Unfortunately, the quantity of alunite available for potash is not known. From such of our cement mills as are equipped with potash recovery plants we secured, in 1918, 12,652 short tons of crude potash containing 1,549 tons of K_2O. And from our blast furnaces and silicate rocks we got a matter of 310 short tons of potassium oxide. Kelp supplied us with 4,804, molasses distillery waste 3,467, beet sugar refineries 1,374, and wood ashes 673 short tons of K_2O.

WEIGHING AND LOADING A CARGO OF POTASH ON A SHIP AT HAMBURG

What store of potash may still be hidden underground in the United States is quite unknown, but inasmuch as potash is associated in Alsace and Saxony with the salt beds of prehistoric seas, there is ample reason to believe that similar occurrences here may be indications of a like if not a greater wealth of subterranean potassium.

Doctor George Otis Smith, Director of the U. S. Geological Survey, has said: "We have been searching for potash on a very small, even a picayune, scale. For instance, there may be and probably are certain points in our underground deposits of salt where conditions were favorable for potash to be deposited. We have put down one hole in an area of 98,000 square miles, which is like taking just one look in a hay mow for a missing needle."

HARDENERS FOR CONCRETE FLOORS

MANY preparations are at present on the market for preserving concrete floors and for preventing the large amount of dust which is ordinarily associated with floors of this kind. At the request of one of the government departments, an investigation has been conducted by the U. S. Bureau of Standards, into the relative merits not only of a number of these patented preparations but also of the so-called "home treatments." For this work several panels in one of the laboratory buildings were treated with the various compounds and their condition after about two years of wear has been noted. The results, while only approximate, give a fair indication of what may be expected from treatments of this kind. The data thus obtained are combined in a mimeographed circular which the Bureau has prepared for distribution. The trade names of the various compounds have been omitted from the circular but information is given of the composition of the various substances.

Automatic Printing of Radio Messages*

Typewriter, Controlled by a Perforated Tape, Which Translates Morse Code Into Type

ONE of the recent developments in wireless telegraphy, which, as we have already announced briefly, was demonstrated by Mr. A. A. Campbell Swinton during his address on November 17 to the Royal Society of Arts, is the automatic printing of wireless messages in roman type. Several systems of printing telegraphy are in use on ordinary lines, but the ingenious method designed by Mr. F. G. Creed is, we believe, the only one that has been adapted to the printing of wireless messages. High-speed wireless reception in various forms is being used to an increasing extent, and Morse code messages are recorded by optical and mechanical methods, as well as by an instrument analogous to a phonograph; but the actual printing of the words in ordinary type on a paper strip presents obvious and very great advantages.

That this result has been rendered possible of achievement is mainly due to the greatly improved methods of amplification of the signals received now available, which have enabled current impulses of sufficient strength for the actuation of the necessary relays to be obtained from the minute oscillations in the receiving aerial. Briefly, the system consists in a combination of the existing printing telegraph apparatus designed by Mr. Creed with the latest arrangements of groups of thermionic valves such as those devised by Capt. L. B. Turner and other workers, who carried on important researches in this direction during the war.

In the Creed system, whether for wireless or line transmission, the message is first translated into the Morse code by punching a perforated strip of paper in an apparatus, with a typewriter keyboard, so contrived that each key perforates the strip, by a solenoid operated mechanism, with the Morse equivalent of the letter in question. This strip, exactly as in the case of automatic Wheatstone working, is passed through the transmitting instrument, which sends out current impulses in the ordinary way in the dots and dashes of the Morse code. These, in ordinary telegraphy, go direct into the line, but in wireless working they are used to actuate a special transmitting contact maker, forming the equivalent of a high-speed relay-operated Morse key. Messrs. Creed and Co. have developed several sizes of transmitters for this purpose, including one suitable for very powerful installations, worked by an electro-pneumatic relay arrangement, and capable of dealing with as much as 300 kw. This has eight sets of contacts in parallel, each breaking under a powerful air-blast.

The waves at the receiving station are picked up by a thermionic-valve receiver, and considerably amplified by a number of valves in cascade in the manner employed in connection with other methods of recording. Current impulses are thus supplied to the relay magnet, forming part of the apparatus known as the Creed receiving perforator. This is of the same form as that used in line telegraphy, and, as employed hitherto for wireless reception, is worked by compressed air, although the company is now developing an electrically driven pattern on a mechanical principle, which is simpler and more compact, and dispenses entirely with compressed air. The Creed air-engine relay used in the instrument is a very interesting piece of apparatus. The tongue of the electrical part of the relay, instead of operating electrical contacts, actuates a very small slide valve controlling a little auxiliary piston, which moves the slide valve of the larger main piston. This, by moving in one direction or the other, drives forward one or other of the perforating punches, through a system of levers.

A very ingenious device arrests the motion of the strip while the holes are being punched. The strip from the receiving perforator, which is still in the Morse code, is the exact counterpart of that used at the transmitting station, with holes side by side to indicate dots and staggered to represent dashes, and a continuous row of holes down the center for feeding purposes. The arresting action is effected by a plunger being thrust forward between the teeth of a spur-wheel on the shaft of the feed-sprocket. The holes are punched opposite each other if the second punch moves forward soon enough after the first for this wheel not to have advanced

*From *Nature* (London), Dec. 9, 1920, pp. 472-474.

AUTOMATIC TYPEWRITER OPERATED BY A PERFORATED TAPE WHICH TRANSLATES THE MORSE CODE INTO PRINTED CHARACTERS

a whole tooth pitch, so that the arresting plunger, in reaching the bottom of the space between the teeth, really brings the paper back a little way. On the other hand, if the wheel has advanced by a whole tooth pitch or more, the plunger engages in the next space, and the second perforation is advanced beyond the first. A Creed receiving perforator is seen in the center of Fig. 1.

The perforated strip is then passed on to the Creed printer. The great feature of this remarkable piece of apparatus is that it forms an automatic typewriter controlled entirely by the position of the holes in the perforated strip, and translates Morse code into printed characters. It is impossible here to do more than to indicate the general principle on which the instrument works, although it is on the perfection of the design of details that much of its success depends.

The perforated paper strip is fed past a group of spring selecting needles, ten on each side, and when it is momentarily at rest with the portion corresponding to a letter opposite the needles, a certain number, forming a pattern corresponding to the letter, protrude through the holes in the strip. Each needle which has thus advanced causes, in a way indicated later, a change in the position of one of a pack of thin steel strips or sliding valve plates. These valve plates lie between two fixed perforated plates, and are themselves perforated in such a way that the position assumed for each combination of the selector needles corresponding to a letter in Morse on the strip causes coincidence of the perforations at one point only, so that there is a clear aperture through the whole pack in a position corresponding to a letter. The bottom plate is supplied with compressed air at the moment in the cycle of operations corresponding to the printing of a letter, and each aperture in the fixed top plate communicates with a small cylinder, in which moves a piston actuating one of the type bars, through levers like those of an ordinary typewriter. Thus a letter is printed corresponding to the position of the coincidence of the valve-plate apertures.

The arrangement whereby a variable feed is given to the strip, according to the length of the letter, is combined with that for actuating the valve plates in accordance with the selection made by the needles. A reciprocating feed-rack is provided, which, when required, can gear into a spur-wheel on the same shaft as the feed-sprocket. The length of its downward travel while out of gear depends upon the point where it is arrested by the projection of one of a group of spacing levers. Normally, these levers are pushed out of the way by the selecting needles, but where neither of a pair of selecting needles advances—*i.e.* where there is a space signal—a space lever continues to stand out, thus limiting the movement of the rack to the length of the letter. A sideways movement is then given to the rack, putting it into gear and causing the perforated strip to feed forward, by exactly the length of the letter just dealt with, during its return journey. Each selecting needle, as it advances, causes a hinged piece on the corresponding valve-plate extension to move forward and to form a shoulder by the side of the feed-rack, so that the sideways movement of the feed-rack is also the actual cause of the shifting of the selected valve plates. It was mentioned above that there are only ten valve plates, whereas twenty selecting needles are provided. It is only the lower group of ten needles that controls valve plates, but the remainder are required to actuate spacing levers. Although more selecting needles may pass through the strip than those corresponding to the letter in question, only the proper number of slide valves are acted upon by the rack, on account of the limitation of its travel by the spacing levers. There are several other features, including the method of withdrawal of the selecting needles and the timing of all the various operations by means of cams, which we cannot dwell upon. The whole apparatus, including a small attached air-compressor, is driven by an electro-motor, so that no external source of compressed air is required.

Messrs. Creed and Co. have also developed an improved form of printer, in which compressed air is dispensed with, and the type characters are mounted on a circular disc and hit from behind by a little selecting hammer which is caused to stop at the part of the revolution corresponding to a letter by a circular group of selecting levers. This form of the apparatus is much more compact than the original instrument, and has a much higher printing speed; but we understand that it has not yet been adapted to wireless reception.

The Creed system with compressed-air working, as adapted to wireless reception, is capable of a speed of transmission of about 180 words a minute, which is in excess of the speed of the printer; so that, in order to obtain the full capacity, two printers would have to be installed for one receiving perforator. The improved printer, however, will be capable of keeping up with the receiver, even in its improved form, and will be able to deal with something like an increase of 50 per cent in the speed of transmission. Apart from considerations of traffic, high transmission speeds present advantages in that there is more chance of the message being completed without interruption by atmospherics or other extraneous effects. Very successful experimental working has been carried out between Cologne and the War Office station at Aldershot, and a wireless printing equipment of this kind is to be adopted between Brussels and a large station in the Congo district.

NEW STEEL ALLOY FOR PERMANENT MAGNETS

A DETAILED description of this alloy is given in the *Proceedings of the Physico-Mathematical Society of Japan* for March, 1920; a brief abstract is given in *Science Abstracts*. A favorable range of the constituents is: C, 0.4-0.8 per cent; Co, 30-40 per cent; W, 5-9 per cent; Cr, 1.5-3 per cent. Its best quenching temperature is 950° C., and the best quenching bath a heavy oil. The steel requires almost no heat treatment in order to be used as a permanent magnet in electrical instruments. The values found for the coercive force varied from 215 to 257, or about three times greater than that of the best tungsten steel hitherto known. Its residual magnetism is also greater than that of tungsten steel. The Brinnell hardness numbers for the alloy were 444 (annealed), and 652 (quenched); the corresponding Shore numbers were 38 and 55. The hysteresis loss was 909,000 ergs (best tungsten steel 209,000). When artificially aged by heating in boiling water for 40 hours, there was a slight increase in residual magnetism, this having taken place in the first three hours' heating. Repeated shocks by fall caused the residual magnetism to decrease from 854 to 800, after 850 falls of 1 meter upon a concrete floor. The residual magnetism increases rapidly with the dimension ratio up to the ratio 20, after which it is unaffected by the ratio. The steel when quenched is mechanically very hard, and has a very fine microstructure. It is specially suited for short bar magnets.

STORED ELECTRIC HEAT FOR A SPINNING MILL

A SWISS spinning mill which has its own waterpower is also connected to the Zurich Canton Electricity Works so that it can obtain current at night on very favorable terms. Hence the old steam heating installation has been converted for electric heating and a hot water accumulator has been added. Steam is generated in the boiler by an electric coil. When the maximum permissible temperature is attained, say, at 4:30 A. M., the boiler is automatically cut off from the circulating system, so that it shall not give out its heat too soon, and the circulating system is fed during the rest of the night direct from the heating coil, so that rooms are kept warm. When the night current is automatically cut off and the working day begins, the boiler is reconnected to the circulating system, and commences to give out its stored-up heat.—F. Rutgers, *Bulletin, Schweiz. Elektrotechnischer Verein*, July, 1920. Abstracted through *The Technical Review.*

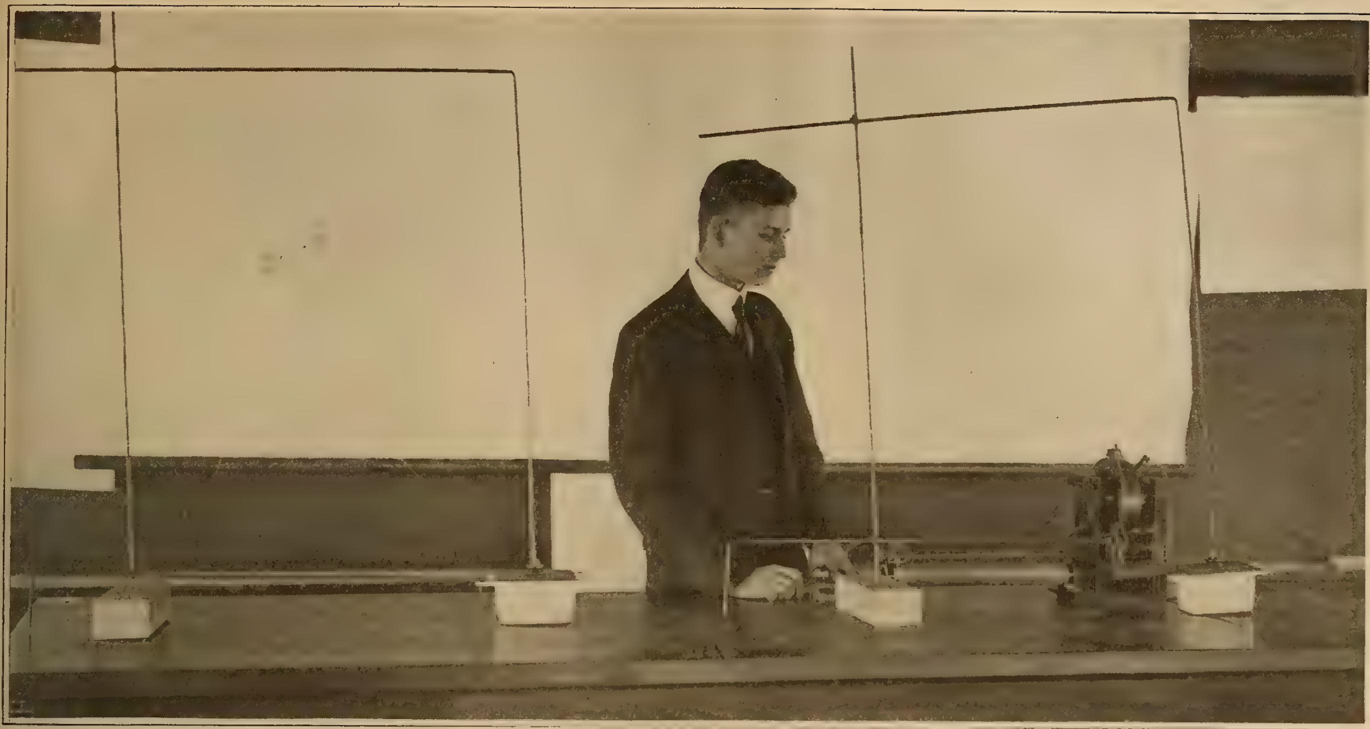


FIG. 1. CIRCUIT PRODUCING RADIO WAVES (*AT RIGHT*) AND (*AT LEFT*) CIRCUIT IN RESONANCE THEREWITH

Radio Communication

Elementary Explanation of the Principles of Radio Telegraphy and Telephony

By J. H. Dellinger, Physicist

Despite the fact that radio telegraphy and telephony is now an old story and although countless youthful experimenters throughout this land are familiar with the principles underlying these forms of communication, there are many men to whom the transmission of messages through space is still a deep mystery. For this reason we believe that the following paper by J. H. Dellinger of the staff of the U. S. Bureau of Standards, which was recently delivered as a popular lecture and which gives a very elementary explanation of radio communication will be welcomed by many of our readers.—Editor.

MESSAGES are now sent without wires between any points on the earth's surface, in the air, or under the ocean. It is possible to sit down to the telephone in your house and talk to persons not only in distant cities but to persons sailing on the ocean or flying in airplanes. The principles which make wireless or radio telephony possible are really not difficult to grasp. While a great deal of mystery has been made of radio, as a matter of fact everything about it is simply a part of principles and ideas well known to science. Since the results achieved in wireless communication are somewhat striking, the newspapers lose no opportunity to use them to incite the wonder of people.

The radio telephone is not a particular instrument; that is, when you talk into a radio telephone you do not necessarily talk into anything different from the ordinary telephone on your desk. Sometimes people talk of a radio telegraph or even of a radio, indicating an idea that some particular, wonderful kind of apparatus accomplishes the feat of communicating from one place to another without wires. As a matter of fact, radio is a system or method involving a great many instruments and appliances. Some of the instruments are very interesting indeed, among them being the electron tube of which more will be said later.

The history of radio is all comprised within our own lifetime, and has been a steady conquest of distance. The rising line in Fig. 2 shows for any year since 1897 the greatest distance which had then been obtained by radio communication. It increased from three-fourths of a mile the first year, when Marconi performed his startling first experiment, to thirty-four miles the next year across the English channel, and so the distance has steadily risen. Last year the distance finally rose to 12,000 miles. This is the limit, since 12,000 miles is half way round the earth. We cannot communicate any further than this unless we exchange signals with other planets. To be sure the newspapers had us communicating with Mars in April, 1920, but this must be discounted.

The word "radio" suggests its own explanation. It means to radiate. Radio communication is carried on by means of waves which are radiated from one place and received at another. These radiated waves are electric waves but they have all the characteristics of wave motion possessed by other kinds of waves, such as sound waves or even the simple waves produced in water when a pebble is thrown into a pond. Much can be learned about the way radio waves act by watching the spreading out in circular rings of ripples on water. Other simple types of waves are also produced by ordinary mechanical means. One can easily produce waves on a rope by shaking the free end. This illustrates that a wave always consists of some sort of to-and-fro motion. Waves can be slow or fast and of different wave length. We cannot see electric waves, as we see ripples or the waves on a rope, but there is nothing special or mysterious about them. We cannot see sound waves. If a tuning fork is struck, it gives off sound waves, which, starting at the tuning fork, travel out

into the air in all directions like the ripples referred to.

Sound waves are produced by the motion of the metal prong of the tuning fork. As the prong moves back and forth it causes the air next to it to move back and forth. This motion is handed on to the surrounding air and so moves out to a great distance in the air just as the ripple on the pond spreads out. The slight to-and-fro- motion of the air spreading out in this manner is called a sound wave.

Electric waves also consist of a certain kind of to-and-fro motion. Just as the motion of the tuning fork causes alternating pressure in the surrounding air, similarly whenever an alternating electric current flows in an electric circuit the to-and-fro motion of the current causes alternating electric pressure in the space next to the wire. This to-and-fro or alternating electric pressure in the space surrounding the wire affects the surrounding space and spreads out in exactly the same way as a sound wave in air. Fig. 1 shows a simple electric circuit (rectangle of wire) arranged so that an alternating current is produced in the wire. When the key is pressed a spark occurs at the spark gap, which lets one know that an electric current is flowing. It is to be noted that this apparatus produces at the same time sound waves, light waves, and electric waves. The electric waves are also called radio waves, and it is by means of them that radio communication is carried on.

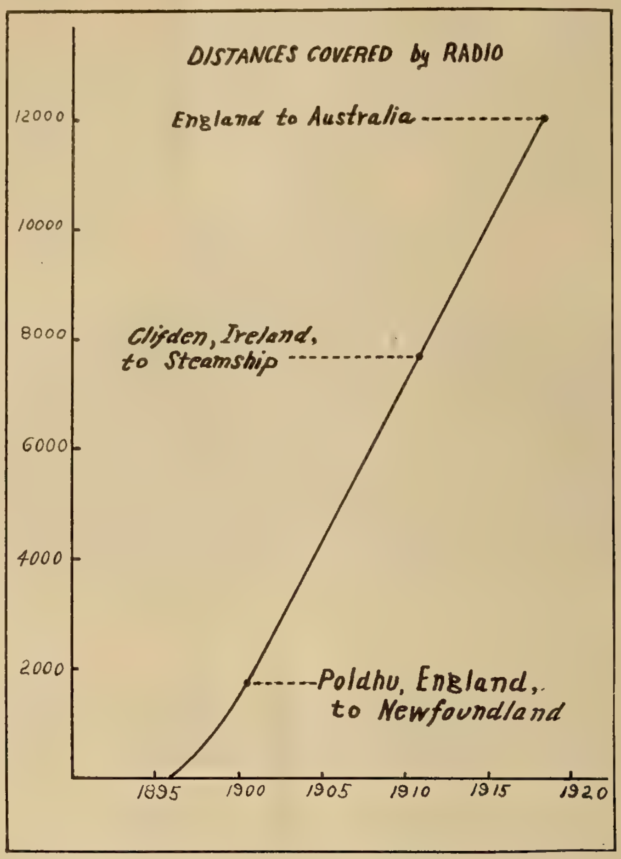


FIG. 2. PROGRESS OF LONG DISTANCE RADIO TRANSMISSION

It is an interesting fact that radio waves are really of the same kind as light waves. We are all familiar with light waves, and it should help to make radio waves less mysterious to know that they are both electric waves. The difference between light and radio waves is the frequency of alternation. Thus electric waves are much more common things than is sometimes supposed. Electric waves are used for many purposes, their use depending on the frequency of the waves. This is shown by the following table showing the frequencies of the various kinds of electric waves. By frequency is meant the number of vibrations per second or the number of to-and-fro alternations of the electric pressure as the wave travels out through space.

Waves Produced by	Vibrations per Second
Commercial Alternating currents	25 to 500
Telephone Currents	16 to 3,000
Radio	10,000 to 30,000,000
Heat and Light	3,000,000,000,000 to 3,000,000,000,000,000
X-Ray	3,000,000,000,000,000,000

All of these waves travel at the same speed. These electric waves are of an entirely different nature from sound waves. Sound waves are not at all electrical; they consist of actual to-and-fro motions of the air particles and travel with a speed of about 1,000 feet per second. The speed at which electric waves travel is much greater than this; it is so great that the passage of any kind of electric wave is practically instantaneous. The various kinds of electric waves shown in the table are much alike in many ways but they have some characteristic differences.

The waves are radiated and spread out more effectively the higher the frequency. The ordinary low frequencies used in the alternating currents which light our houses alternate very slowly. Such waves travel readily along wires. In order to get a wave which will travel effectively through space, higher frequencies must be used; that is why the frequencies shown in the table for radio communication make a large number of vibrations per second.

It is to be noted that these frequencies are not, however, as high as the frequencies of light waves. Light waves travel in straight lines, which is one of their characteristic differences from the low-frequency waves of alternating-current power, which follow along wires. Radio waves are intermediate in character between the two, and can travel in straight lines and also travel along conducting wires. Radio waves are different from light waves also in that they go through ordinary walls of buildings and other obstacles which are opaque to light.

We are now ready to consider how an electric wave may be produced.

Whenever there is an electric circuit in which alternating current is flowing an electric wave starts out just as a sound wave starts out from a vibrating tuning fork. A powerful sound can be produced by using a very large tuning fork, and similarly a powerful electric wave is produced by making some part of the electric circuit large in dimensions. The antennas used in radio work, as is well known, often consist of long conductors supported on very high towers. A mechanism for producing a radio wave, therefore, is simply an enlarged or extended portion of an electric circuit in which an alternating current is made to flow. In the space near the antenna, alternations of electric pressure are produced just as alternations of air pressure are produced around a tuning fork. At any instant the electrical condition of the space around an antenna which is sending out radio waves could be shown by a diagram such as Fig. 5. The arrow on the line extending between the antenna and ground indicates that the electric pressure at a particular moment is in the direction indicated. When the current changes in direction, the direction of this electric pressure will be reversed and the electric pressure already mentioned will have handed

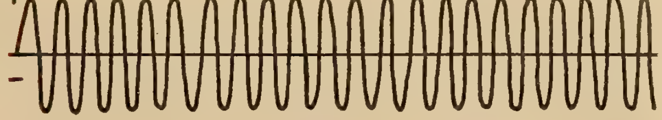


FIG. 3. CONTINUOUS WAVES

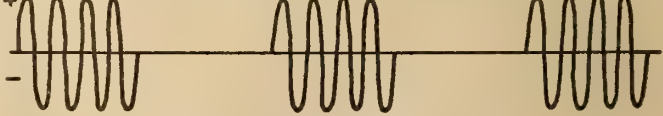


FIG. 4. INTERRUPTED WAVES

on its effect to the surrounding space. Thus the effect of an electric pressure is handed on and spreads out through space, the direction of this pressure at any point constantly alternating as the direction of the current in the antenna producing it alternates. Lines of electric pressure alternating in direction are thus constantly spreading out from the antenna just as the ripples spread out on a pond. Something very similar to the ripples would be seen if, in some way, the alternations of electric pressure could be made visible and a person were to look down from above upon the antenna and the space around it. The waves of electric pressure spreading out and successively alternating in direction would look something like the lines shown in the upper part of Fig. 5. The waves spread out in all directions and go to great distances.

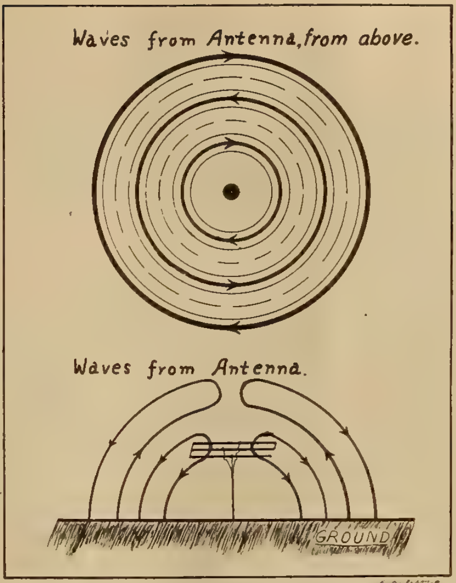


FIG. 5. PRODUCTION OF WAVES AROUND AN ANTENNA

Now think of what is happening at a distance from the antenna. As the wave passes any point there is an alternation of electric pressure going on continuously at that point. The alternating electric pressure or wave action at that point could be illustrated by the wavy line of Fig. 3. The portions of the wave above the horizontal line correspond to the electric pressure in one direction, and the portions below correspond to the electric pressure in the other direction. This can be understood by thinking again of the ripple on the water. Suppose there is a cork or other floating object on the surface of the water at a distance from the place where the ripple starts. As the ripple takes place, the cork rises and falls, partaking of the to-and-fro motion of the surface of the water. Or consider the sound wave. As the sound wave passes out through the air, it will set in vibration any object which is capable of taking up the motion. Suppose, for instance, that a sound wave produced by a tuning fork passes a second tuning fork which is in tune with it, that is, having the same natural pitch or frequency of vibration as the first tuning fork. The to-and-fro motion of the air will start the second tuning fork into motion. This can be readily shown with two tuning forks, striking one of the forks, thus producing a sound wave. It can be proved that the second tuning fork is set into vibration by grasping the first with the hand so as to prevent its further motion. A sound from the second one can then be heard. The same thing is sometimes illustrated in a room. If a note is sung or produced on some instrument, a response may be heard from one of the strings of the piano or from a loose portion of a chandelier or other resonant object in the room.

An electric wave can produce an effect at a distance in just the same manner. In any electric curcuit the moving wave of electric pressure can produce an electric current alternating with the same frequency as the wave. This is also readily illustrated just as the effect of one tuning fork on another was illustrated. Taking the same electric circuit with its spark gap, which was shown before, and allowing an alternating current to flow in it, it sends out an electric wave which can act on another electric circuit entirely disconnected from the first. In Fig. 1 the response in the second circuit when a current flows in the first circuit is shown by the fact that the indicating tube in the second circuit lights up when a current flows in the first circuit.

In order that this may take place, the second circuit must be in tune with the first. That is, it must be arranged to respond to the frequency of alternation possessed by the first circuit and the wave which it sends out. This is just like what happens with the two tuning forks and the sound wave. The second tuning fork does not respond to the wave from the first unless the two are in tune. This can be shown by placing a bit of wax on one of the prongs of the second tuning fork, changing the pitch of that fork. When the first tuning fork is struck under these conditions it can readily be demonstrated that the second fork does not respond. In the same way the electrical arrangements in the receiving circuit which are used to receive radio waves must be such that the receiving circuit is electrically in tune with the radio wave. By this means the radio receiving circuit can pick out the particular wave which it is desired to receive and not be affected by other waves. This is fortunate because otherwise the interference between different radio messages would be hopeless. It would be just as though every sound wave which passed through the air set absolutely everything which it touched into vibration.

As has been mentioned the frequency of alternation of radio waves is very high, so high, in fact, that a sound wave of such frequencies could not be heard. Suppose, for instance, that an ordinary telephone receiver was placed in the circuit which is receiving a radio wave. The electric currents of the same frequency as the wave frequency tend to cause motions of the telephone receiver diaphragm. These motions are, however, of such great frequency that no audible sound is produced. In order to permit the radio wave to be received and transformed into a sound it is therefore neces-

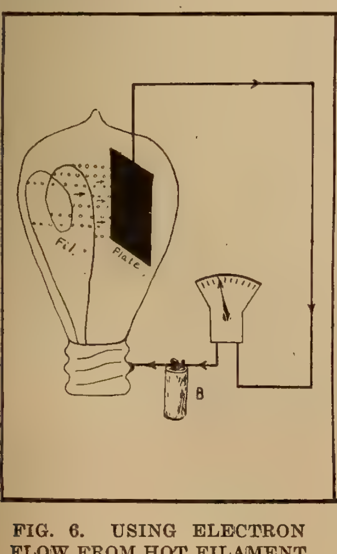


FIG. 6. USING ELECTRON FLOW FROM HOT FILAMENT

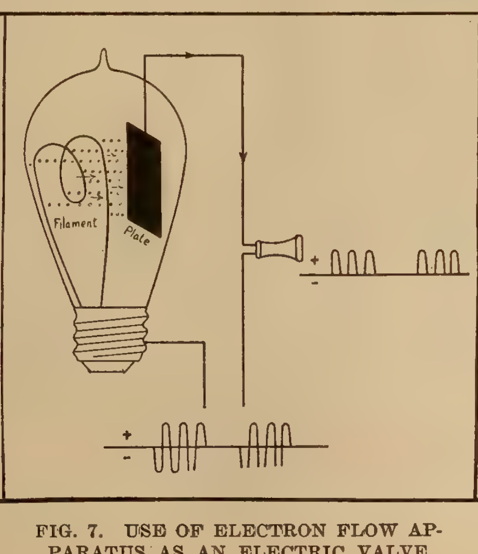


FIG. 7. USE OF ELECTRON FLOW APPARATUS AS AN ELECTRIC VALVE

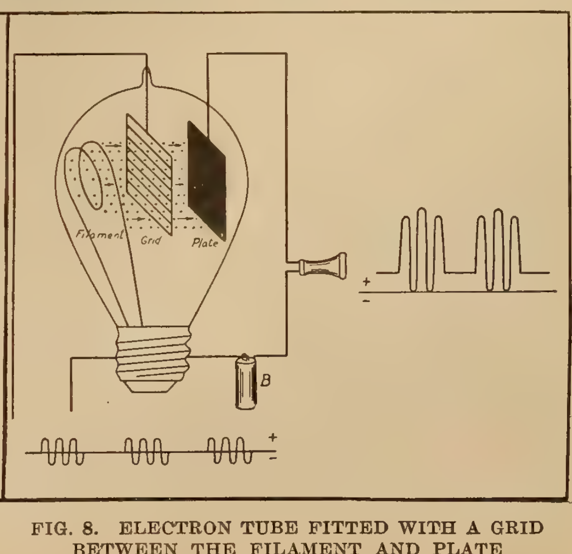


FIG. 8. ELECTRON TUBE FITTED WITH A GRID BETWEEN THE FILAMENT AND PLATE

sary to break up the radio wave in some manner. This is done in radio telegraphy by interrupting the wave completely so that it consists not of a single regular series of alternations but of a succession of groups of such alternations, that is, instead of the continuous wave shown in Fig. 3 we use the interrupted wave or group of waves illustrated in Fig. 4. The frequency of the interruptions or of the groups of waves is the frequency which can be heard.

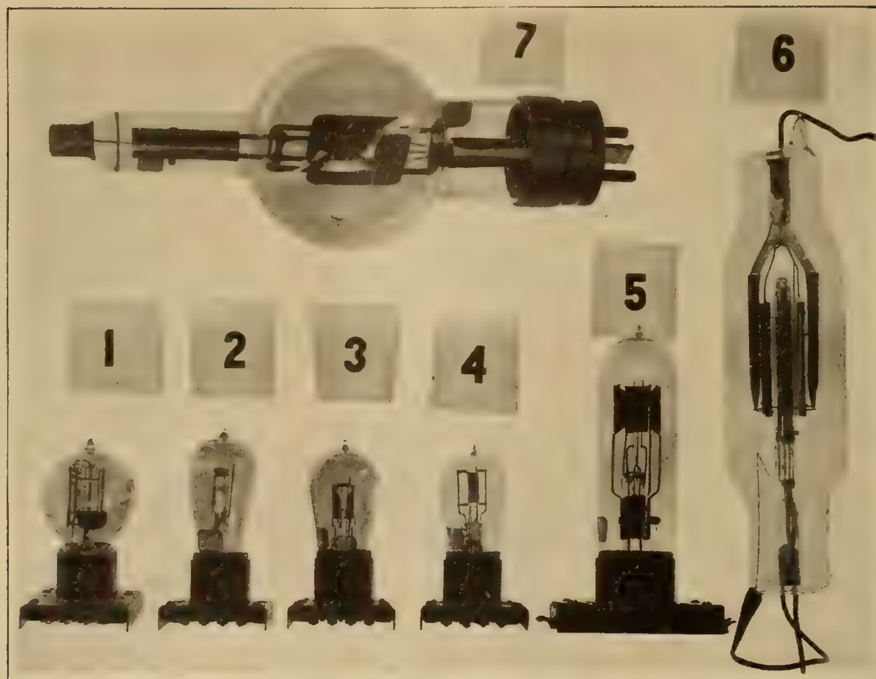


FIG. 9. VARIOUS TYPES OF ELECTRON TUBES

There is another thing that is to be taken into account before it becomes possible to translate the received radio current into a sound that can be heard. When one of the groups of alternations shown in Fig. 8 acts on the telephone receiver it causes no motion of the diaphragm because each variation of the current in one direction is immediately followed by the current in the opposite direction so that the resulting effect of the group of waves upon the telephone receiver diaphragm is no motion at all. It is therefore necessary, in order to convert the current into a sound, to use something else with the telephone receiver. This something else must be such as to make the current flow through the telephone receiver in only one direction. It must allow the electric current to flow through it in one direction and stop current which tries to flow through it in the opposite direction; that is, it must be some sort of electric valve. The effect of such an electric valve may perhaps be understood more clearly by taking a sheet of paper and placing it upon Fig. 4 so as to block out the lower half of the waves shown. This leaves only the upper halves of the little groups of waves and this is exactly what the electric valve does. It results that successive impulses of current flow through the telephone receiver and all of these tiny impulses in any one group add their effects together and produce a motion out of the telephone diaphragm. The interval between one group and the next permits the motion of the telephone diaphragm to subside and this intermittent motion causes what is heard as a note in the receiver.

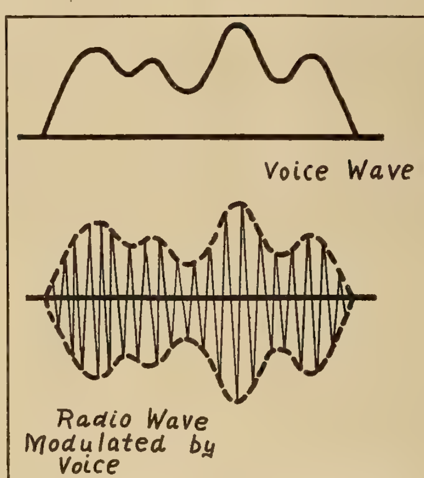


FIG. 10. VOICE WAVE CARRIED BY RADIO WAVES

A number of devices are used to perform the electric valve action which has been mentioned. The most interesting and most effective device of this kind is the electron tube. The electron tube is a very simple device which looks more like an ordinary incandescent lamp bulb than anything else. Your attention is particularly invited to the principles upon which it operates since this is the most important of the apparatus used in radio. While experimenting in the development of the incandescent lamp Edison made the discovery that an electric current could be made to flow in the empty space inside the bulb near the hot filament. If a middle plate is placed inside of an incandescent lamp bulb near the filament (Fig. 6) and if by means of a wire through the glass this middle plate is connected by wire through a battery and an indicating instrument to the filament, a current will flow as indicated by the instrument. A current is flowing in the wire and also flowing across the empty space between the filament and the plate. By much patient scientific research, scientists have found out that this current taking place in the lamp consists of the flow of a stream of very small electric particles called electrons. These electrons are shot out into the surrounding space in all directions by the hot filament. The electrons may be said to fill the bulb like a vapor. They move at random in all directions unless there is an electric force to make them move in some particular direction. The battery connected in the circuit outside the bulb supplies an electric force which acts between the filament and plate and makes the electrons move from the filament to the plate. If the battery is disconnected, there is no current, and as many electrons as strike the plate fall off again into the bulb. The current depends on the number and speed of the electrons. The battery is what gives them their speed in the direction filament to plate.

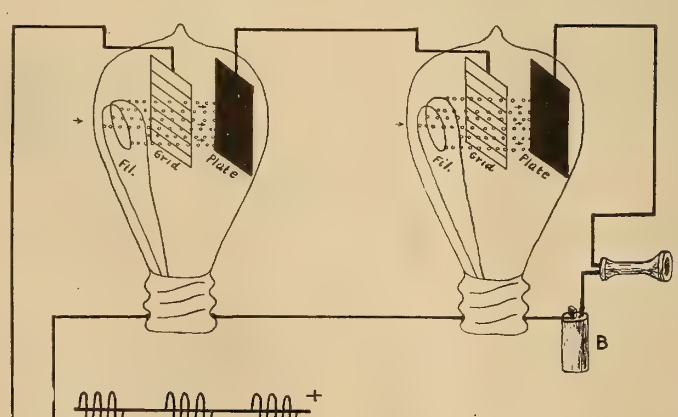


FIG. 11. THE PRINCIPLE OF THE AMPLIFIER

The battery performs much the same action as a steam pump would if the bulb were a room into and out of which steam pipes were connected. If the pump were disconnected, there would be no flow of steam and when the pump is connected, steam is made to flow into and out of the room and through the pipe.

The point of all this is that the electron flow in the bulb has a valve action. The electrons are emitted by the very hot filament and can be

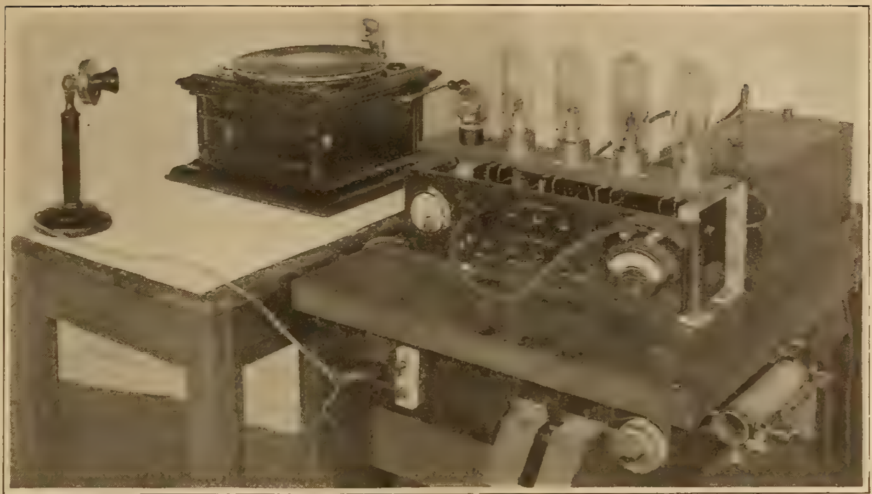


FIG. 12. PHONOGRAPH PLAYING INTO A RADIO TRANSMITTING SET

made to flow toward the plate by connecting a battery in the proper direction. If the connections of the battery are reversed, however, no current will flow because there is no such emission of electrons from the plate, which is cold, the electric force produced by the battery in this case has nothing to work on and can do nothing except prevent the flow of electrons out of the filament to the plate. It should be clearly understood before going further that the action of the electron tube thus depends upon the fact that an electric force can be applied in one direction which causes an electric current from the filament to the plate, but that if this electric force is reversed no current flows. The device gives exactly the electric valve action needed in order to make the incoming radio signals produce sound in a telephone receiver. Suppose that the bulb shown in Fig. 6 is connected up to a radio receiving circuit in place of the battery. Suppose also that the indicating instrument is replaced by a telephone receiver. This is shown in Fig. 7. The pulses of current in the radio receiving circuit similar to those of Fig. 4 produce electric force inside the bulb between the filament and plate which alternates in direction just as the pulses of current do. On account of the valve action, current can flow through the bulb only in one direction and consequently the pulses of electric force in one direction only are effective. As a result, pulses of current flow through the telephone receiver in groups, the pulses being all in one direction. This causes a note in the telephone receiver, as already explained.

It might seem that these small electric particles, called electrons, are very remote from any practical use. The study of electrons has in fact been advanced by purely scientific research not at all connected with any applications. By means of the electron tube, however, very practicable use indeed is made of electrons and their importance is recognized commercially. Scientific research work which has been done in this connection has revolutionized radio and provided a means for great improvements in ordinary wire telephony and also in other uses of electricity.

An improvement in this electron device can be made which very greatly extends its power and usefulness. As shown in Fig. 8 a grid of very fine wire can be placed in the tube between the filament and the plate. The grid is placed closer to the filament than to the plate. The electrons which are emitted by the filament can move freely between the grid wires. If by means of a battery or something else an electric force is established between the filament and the grid, this electric force causes electrons to move away from the filament toward the plate and since the grid is placed much closer to the filament the electric force makes the electrons move much faster than the same electric force between the filament and plate would. Very few of the electrons are taken by the grid, and a very small current thus goes through the wire connected to the grid. Thus a very small current to the grid controls the flow of a much larger current to the plate. Hence a larger current can be taken out of the tube than is put into it. A small electric force acts between grid and filament causing a large electron flow from filament to plate. There results a relatively large flow of current in the apparatus connected outside the tube between the plate and filament. This device is commonly called an electron tube. It magnifies or amplifies electric currents. It accomplishes the control of a large amount of power by a small power. This is just the same

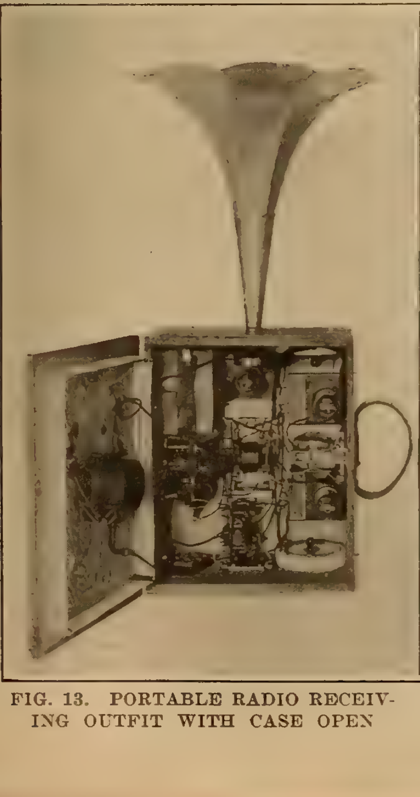


FIG. 13. PORTABLE RADIO RECEIVING OUTFIT WITH CASE OPEN


FIG. 14. LOUD-SPEAKING OUTFIT RECEIVING CALLS FROM SHIPS AT SEA

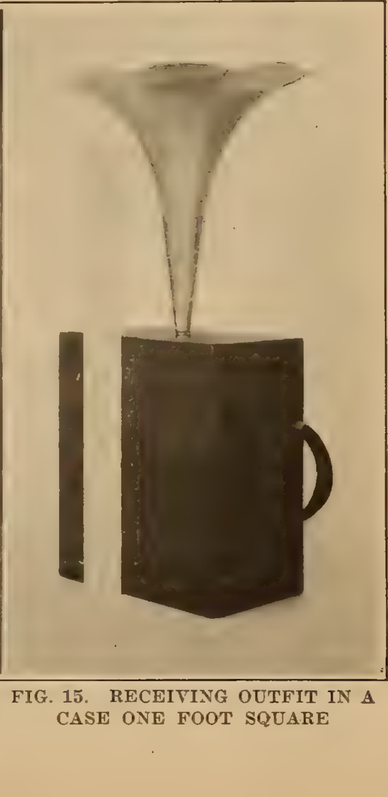


FIG. 15. RECEIVING OUTFIT IN A CASE ONE FOOT SQUARE

thing that a gun does—pressing the trigger several times in a repeating pistol is like the action of the tube with successive pulses of electric force. The grid corresponds to the trigger and the plate to the gun barrel.

A number of forms of electron tubes as used today are shown in Fig. 9. They are used to receive radio waves and make signals just as the simpler device shown in Fig. 6 does, and they amplify the signal as well as make it audible. This is suggested to the mind by the larger wave shown with the telephone receiver in Fig. 7 and Fig. 8. On account of the control of the plate current by a smaller grid current, the electron tube makes possible very wonderful feats. It is worth while to note the explanation quite carefully as it will be shown presently that this explanation contains all the most important features of radio telephony.

It is perfectly possible and quite easy to take the magnified output from an electron tube and pass it into a second electron tube, using that to make a still further amplification of the current. Using one tube after another in this way, we obtain what is called an amplifier. Two tubes joined together in this way are shown in Fig. 11 and the process can be repeated several times using a number of tubes. The current is increased by each tube and handed on to the next without any change or distortion of the current even though it passes through several stages.

The amplifier is of the greatest importance both in radio and in long-distance wire telephony. It reduces the amount of power that must be used in a radio transmitting station because when an amplifier is used in a receiving station, signals can be received which are far too feeble to be received without an amplifier. By means of amplifiers to which were connected loud-speaking telephones, demonstrations have been given in which an airplane more than a mile in the air addressed large crowds on the streets of New York. One of President Wilson's speeches in the West was spoken into a telephone apparatus and amplifiers were used to make it fully audible to all persons in a very large crowd. The large announcers used in railway stations now make use of amplifiers. By means of amplifiers, submarine vessels can receive radio messages when entirely submerged. It is an interesting fact that an amplifier can be made so powerful that no input current at all is required. This does not mean that it is a perpetual motion machine, because the power to operate it must be supplied by the battery that is connected in the plate circuit of the tubes. It does mean, however, that the electron tube can be used to generate alternating currents as well as to receive and to amplify them.

Thus far we have discussed only signals such as are used in telegraphy. The voice can be transmitted and received by the same apparatus and principles. The human voice produces sound waves which cause air vibrations of an irregular character. Such a wave may be roughly illustrated as in Fig. 10. The variations in the wave are much slower than the alternations of current used in radio. It is possible to make a radio wave carry a voice wave, and when this voice-modulated wave is received it can be passed through a telephone receiver and the voice heard just as the radio telegraph signals are heard. The principle simply is that instead of breaking up the continuous wave of Fig. 3 by interrupting it, as in Fig. 4, it is caused to vary in accordance with the voice wave and these variations can be made audible. The way in which the voice wave is superimposed upon the radio wave is illustrated in Fig. 10. The alternations of the radio wave are shown by the full lines, and the dotted boundary lines show that the intensity of the wave has been made to vary in accordance with the sound wave produced by the voice. This wave can be received in exactly the same way as any wave in ordinary radio telegraphy—no special apparatus is required for receiving radio telephony. The voice at the transmitting station is heard very clearly. It can be made as loud as desired at the receiving station just as radio telegraph signals can be by the use of amplifiers.

The radio wave is really modulated or molded just as a phonograph record is molded by a sound wave. The means by which this modulation is accomplished is the electron tube. If in Fig. 8 the telephone receiver is replaced by any kind of generator of radio current, then if a person speaks into a telephone transmitter connected between the grid and filament of the tube the variations caused by the sound of the person's voice are impressed upon the radio current in the plate circuit and a modulated radio wave as in Fig. 16 is produced.

A small radio telephone transmitting outfit which is used for demonstration and experimental purposes at the Bureau of Standards is shown in Fig. 12. Music is readily transmitted out into space by playing the music into a telpehone transmitter. A phonograph may be used as shown in Fig. 12. The telephone transmitter is connected to the radio telephone apparatus upon which the electron tubes may be seen.

A receiving outfit usable in demonstrations is shown in Fig. 14. The receiving circuit or antenna is entirely contained within the frame shown in the picture, and electron tube used as a detector and amplifier and the loud-speaking telephone receiver are all visible. A much more compact radio receiving outfit is shown in Figs 13 and 15. The box encloses the electron tubes, the receiving antenna and all necessary apparatus connected to the horn which projects from the box. This is actually a satisfactory receiving set for demonstration and other purposes. It suggests the possibilities of the future. Radio sets of small enough size to use in any ordinary room or in moving vehicles can easily be made even now.

By means of electron tubes, radio telephone messages were successfully transmitted five years ago over a distance of 5,000 miles. Concerts are already being sent out by radio and are receivable by anyone who has an ordinary receiving set. This result has been accomplished by patient research, scientific study and progressive engineering. In Bellamy's "Looking Backward," describing conditions in the year 2,000, an arrangement is described by which people receive music in their houses any time desired by simply connecting a certain electrical instrument. In this particular the dreams of the prophet have been anticipated by eighty years.

USE OF BARBED WIRE AS A PROTECTION AGAINST SURGES

R. NAGEL, writing in *Archiv f. Elektrot*, Jan. 8, 1920, proposes to utilize the glow discharge as a protective device against surges. A loss of energy takes place through the discharge, and this can be accentuated by providing sharp points, from which this discharge can the more easily take place.

It is the opinion of the author that commercial barbed wire might serve the purpose of providing a number of sharp points along a conductor in an easily manufactured form. He describes various tests that have been carried out with a view to determining the most convenient conditions under which the barbed wire should be installed. Various types of barbed wire are on the market, but any material serves. It would be well not to use ungalvanized iron, seeing that the spikes would be liable to rust, and in this way the tips from which the discharge takes place would eventually lose their sharpness and become ineffective. If the whole of the transmission line were made of barbed wire, this would be effective, but it is an unnecessary expense. It would be sufficient to insert lengths of barbed wire in the transmission lines for short distances in the neighborhood of every substation. If the atmospheric conditions are such that it is known that there is a danger zone over a given stretch of the line, as, for instance, over an exposed mountainous stretch, it might be well to use barbed wire in such places. The paper contains the results of tests which have been made with a view to determining the effect produced and the amount of energy that can be dissipated in this way.—*Science Abstracts.*

A New Electric Battery

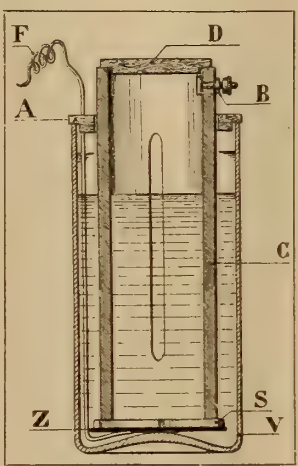
A Cell for Which Remarkable Advantages Are Claimed

A FRENCH inventor named Féry has constructed a new battery for which the following advantages are claimed:

1. *It never contains corrosive salts* whether used in continuous or interrupted service because of the fact that the superficial solution is poor in mineral salts and rich in ammonia.

2. *The salts which are formed by long operation of the battery are deposited in the middle portion of the vessel,* thus leaving the zinc as well as the surface of the liquid perfectly clean.

3. *There is complete utilization of the sheet of zinc* by reason of the circumstance that it always remains clean and wear and tear occurs in a uniform manner. The zinc is not used up in an open circuit, since it is placed at the bottom of the vessel in a solution of chloride of zinc, so that the oxygen and the ammonia are unable to reach it. Even the presence of foreign metals in contact with it (*e.g.*, the solder and the copper wire) do not occasion local wear, since the latter metals are at once covered with a protective layer of zinc. Finally, when the zinc is used up it is only necessary to renew it and also the ammoniacal solution in order to have a new battery. The ammoniacal solution, indeed, can be used again after being filtered, since the ammonium hydrochlorate which it contains remains unaltered.



THE FÉRY ELECTRIC BATTERY

Since a battery made in this manner is much cheaper than the ordinary one which employs manganese dioxide, it seems destined to take the place of the latter.

Writing in *La Nature* (Paris) for Sept. 18, 1920, M. A. Troller says:

Since the depolarizing agents usually employed in batteries are expensive, it has long been endeavored to find some method of substituting the oxygen of the air, which is obtainable everywhere gratis, but no one succeeded in this until M. Féry accomplished the feat during the war. He reasoned as follows:

A battery generally consists of two vertical electrodes immersed in an exciting liquid. It is at the surface of the liquid that the oxygen which it is desired to use as depolarizing agent, is dissolved. But the exciting solution being exposed to air upon its surface, is rapidly deprived of its oxygen by the highly oxidizable metal, zinc. Zinc oxide, moreover, dissolves readily in hydrochlorate of ammonia, which is the exciting liquid most often employed.

To remedy these defects M. Féry arranges the zinc in the form of a horizontal plate at the bottom of the cell element. The positive electrode, which has a highly developed form, remains vertical, its lower end being separated from the zinc only by an insulating cross bar, a few millimeters thick.

As soon as the circuit is closed polarization begins, *i.e.*, hydrogen appears on those parts of the charcoal nearest the zinc, and insulates from the liquid the corresponding portion of the charcoal, so that the current continues to pass by the adjacent surfaces which are polarized in their turn, until the current ceases.

But in the Féry cell, since the charcoal stands vertically above the horizontal position it is the lower part of the charcoal which is covered with hydrogen while the upper part is bathed in a liquid saturated with oxygen, from the air dissolved in the upper layers of the liquid. The result is that there is an electrochemical dissymmetry between the upper portion of the charcoal (immersed in the oxygenated liquid) and its lower part (which is covered with hydrogen).

The whole forms a gas battery arranged in short circuit which constitutes the depolarizing couple. This couple begins to operate at the same time as the principal couple (the zinc and the lower portion of the charcoal). The result is that oxygen is set free from the lower portion of the charcoal and combines with the hydrogen proceeding from the principal couple, while in the upper part of the charcoal hydrogen is liberated and combines with the oxygen in the liquid.

In the accompanying illustration V is a glass vessel; C, carbon cylinder; Z, zinc; F, conducting wire soldered to the zinc; A, ring-shaped lid; D, cover of the carbon; B, binding post attached to carbon; S, wooden cross bar. Thus we see that the *local* couple furnishes automatically the precise amount of oxygen required to depolarize the lower part of the carbon, which with the zinc forms the principal couple. Obviously the more actively the oxygen is dissolved and the fitter the charcoal to utilize the oxygen rapidly, the more rapid the depolarization, hence it is advisable to make use of a special quality of carbon and of a liquid surface as large as possible.

As a result of the operation of the battery zinc chloride and ammonia are formed, the latter of which being lighter rises to the top. Obviously, a moment will occur when the upper portion of the zinc chloride will come in contact with the lower layers of the ammonia, the result being the formation of hydrated zinc oxide with regeneration of the salammoniac. The former at first dissolves in the solution of the latter and is afterward deposited upon the carbon and the walls of the vessel in crystals, whose form vary according to the respective concentrations of the liquid. The crystals deposited in the middle of the cell do not interfere with its functioning but a moment finally arrives when the quantity of zinc oxide deposited is so great that it increases the internal resistance. This is the only practical limitation of the capacity of a cell of any given size. As a matter of fact *since the salammoniac is constantly regenerated* it is not used up and it is possible to employ a very thick piece of zinc, thus obtaining a cell of considerable capacity.

The carbon really acts in this cell like a catalyzer whose mere presence favors the union of the electrolytic hydrogen with the oxygen. M. Féry uses a very pure charcoal mounted and annealed in such a manner as to obtain a definite degree of porosity.

While the cell has a lid to prevent too rapid evaporation the usual fatty body floated upon the liquid is omitted, since this would prevent the absorption of the necessary oxygen. As M. Troller neatly observes this battery actually *breathes* and to cover it with an oil would asphyxiate it.

Remarkable results have been obtained by the battery, which may be stated in brief as follows:

A cell mounted in a vessel 10 cm. square and 22 cm. high. and containing 1 liter of water and 125 grams of salammoniac with a zinc plate weighing 160 grams yields a total energy either in continuous or interrupted service amounting to 125 ampere hours.

THE ISOPERIMETRIC ELLIPSOGRAPH

By J. A. Van Groos

The machine illustrated in the accompanying drawings is built somewhat like an ordinary ellipsograph. The points x and y, Fig. 1, are adapted to run in grooves a_2 and a_1 at right angles to each other. These points x and y are joined together by means of a right-and-left screw z,

which when turned will cause the points to travel toward or away from each other. The machine will make all possible ellipses from a circle to a straight line. It is absolutely exact for these extreme positions of x and y, that is, the circumference of the circle is exactly equal to twice the straight line.

But as shown in the enclosed table of semiperimeters, the semiperimeter gets shorter by about 2 inches in 31, or about 6.4 per cent. This is corrected by means of a cam q, which moves when z is turned. The cam makes a complete revolution while the points x and y move from one extreme position to the other. During the tracing of a certain ellipse, the points x and y and the cam q are stationary with respect to the screw z.

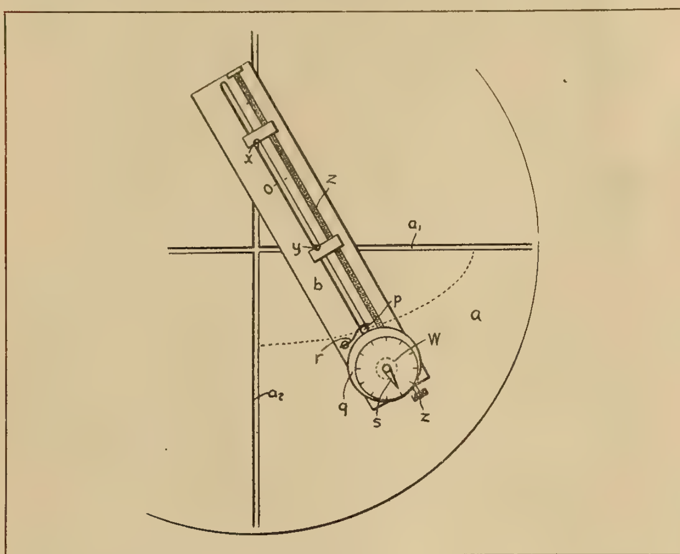


FIG. 1

To illustrate the machine diagrammatically, let MN and RT (Fig. 2) be the grooves; x and y the moving points; CD the limits of x and CP of y. The tracing point is at P. The points x and y must move on the screw z in such a way that when y goes through a distance CP, say CP = 10, x must go through a distance $5\pi - 10$. For if CP = 10, then when x and y are both at C, P will describe a circle with radius 10, and hence with circumference 20π. Also, when x is at D and y at P, P will describe a straight line; hence DP must equal 5π. Therefore

$$CD = 5\pi - 10 = 5.707$$

$$\frac{Cx}{Cy} = \frac{CD}{CP} = \frac{5\pi - 10}{10} = \frac{\pi - 2}{2}$$

$$\text{or}\quad Cx = Cy\left(\frac{\pi - 2}{2}\right)$$

Now assign values to Cy (Col. I Table I); then Cx can be found (Col. II Table I); and $10 + Cx = xP = a =$ semimajor axis (Col. III Table I), while $10 - Cy = yP = b =$ semiminor axis (Col. IV Table I). Also,

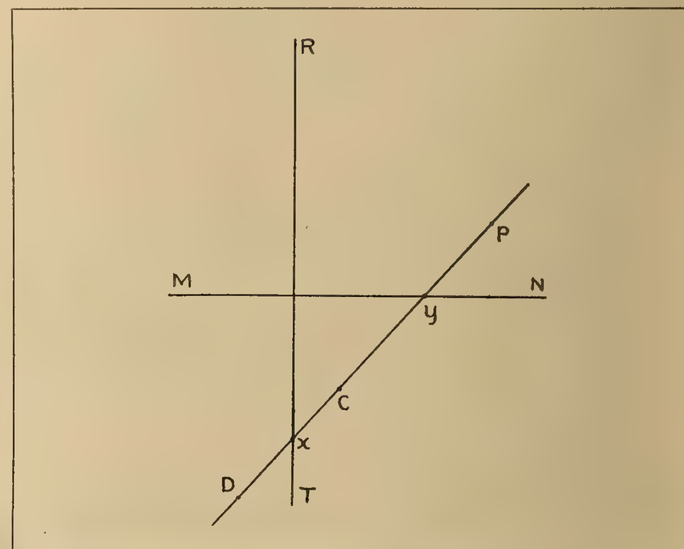


FIG. 2

$$e^2 = \frac{a^2 - b^2}{a^2};$$

hence log e can be found (Col. V Table I). Then get arcsin e from table of trigonometric functions (Col. VI Table I); get E from table of elliptic integrals (Col. VII Table I); get $2a$E or semiperimeter (Col. VIII Table I): and Col. IX Table I shows corrections to be made by cam.

The size of the cam q is readily found. For example, see Table II. I find, by trying different value of b, when $Cy = 5$, that b should have a value between 5.66 and 5.67 instead of 5 as given by Table I.

TABLE I

Cy	Cx	xP=a	yP=b	log e	$\sin^{-1}$ e	E	2aE	Corrections
0.00	0.0000	10.0000	10.00	$-\infty$	0° 0′ 0″	1.5708	31.4159	0.0000
1.00	0.5708	10.5708	9.00	9.719757–10	31° 38′ 8″	1.4564	30.7906	0.6253
2.00	1.1416	11.1416	8.00	9.842617–10	44° 6′ 28″	1.3585	30.2717	1.1442
3.00	1.7124	11.7124	7.00	9.904045–10	53° 18′ 0″	1.2744	29.8526	1.5633
4.00	2.2832	12.2832	6.00	9.940856–10	60° 46′ 18″	1.2037	29.5706	1.8453
4.50	2.5686	12.5686	5.50	9.953842–10	64° 2′ 57″	1.1727	29.4784	1.9375
5.00	2.8540	12.8540	5.00	9.964433–10	67° 7′ 37″	1.1442	29.4265	1.9894
5.25	2.9967	12.9967	4.75	9.968865–10	68° 33′ 50″	1.1312	29.4037	2.0122
6.00	3.1394	13.1394	4.50	9.972908–10	69° 58′ 18″	1.1187	29.3981	2.0178
5.50	3.2821	13.2821	4.25	9.976544–10	71° 20′ 17″	1.1068	29.4013	2.0146
5.75	3.4248	13.4248	4.00	9.979812–10	72° 39′ 54″	1.0955	29.4137	2.0022
7.00	3.9956	13.9956	3.00	9.989790–10	77° 37′ 30″	1.0559	29.5560	1.8599
8.00	4.5664	14.5664	2.00	9.995867–10	82° 6′ 30″	1.0272	29.9252	1.4907
9.00	5.1372	15.1372	1.00	9.999049–10	86° 12′ 33″	1.0079	30.5136	0.9023
10.00	5.7080	15.7080	0.00	10.000000–10	90° 0′ 0″	1.0000	31.4159	0.0000

TABLE II

Cy	Cx	xP=a	yP=b	log e	$\sin^{-1}$ e	E	2aE	Corrections
5.00	2.8540	13.3540	5.50	9.959636–10	65° 40′ 40″	1.1576	30.9172	+0.4987
5.00	2.8540	13.5140	5.66	9.958118–10	65° 14′ 20″	1.1616	31.3957	+0.0202
5.00	2.8540	13.5240	5.67	9.958023–10	65° 12′ 44″	1.16184	31.4254	—0.0095
5.00	2.8540	13.5340	5.68	9.957978–10	65° 12′ 0″	1.16194	31.4530	—0.0371
5.00	2.8540	13.5200	5.6666	9.958067–10	65° 13′ 30″	1.1617075	31.41257	+0.00335

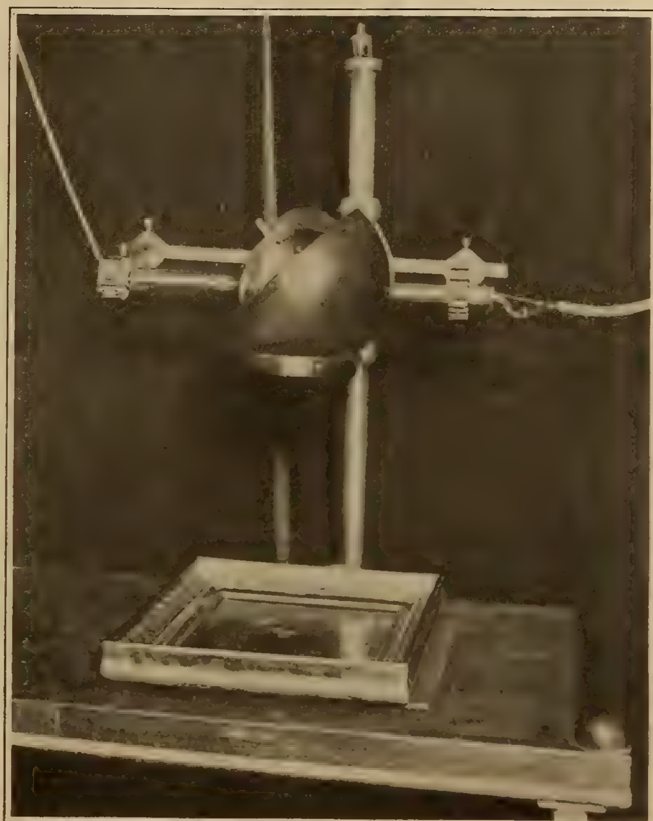
X-Ray Tests of Old Paintings

Remarkable Differences Between Ancient and Modern Pictures Revealed by X-Rays

By May Tevis

IN one of his note books Nathaniel Hawthorne relates the story of a man who, being in possession of a beautiful painting perceived upon close scrutiny that it had been painted not upon a fresh surface but upon the top of an older painting. Inspired by curiosity and imagining, perhaps, that the older picture might represent a greater value, he removed the upper layer of pigment to find, alas, that he had sacrificed a charming painting only to uncover a worthless daub. Had the unfortunate owner lived in this our 20th century, he need have taken no such risk, since researches recently made in several European countries show that the connoisseur now has an admirable implement in the shape of the X-ray with which to supplement his critical judgment concerning the antiquity of pictures and one revealing whether they were painted upon a virgin surface or upon one bearing a previous work of art.

The first researches along this line are said to have been made in Germany in 1914, and they were described by Faber in the *Zeitschrift f. Museumkunde.* Similar studies were pursued in Holland by Dr. Heilbron of Amsterdam, and some very interesting results were obtained by him. More recently a French expert, Dr. Chéron, has obtained results still more definite and more remarkable, some of which are indicated in the illustrations which are reproduced with this article.



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DR. CHÉRON'S APPARATUS FOR MAKING X-RAY PICTURES OF PAINTINGS

The degree of transparency to X-rays exhibited by any body depends upon the number and atomic weight of the atoms composing the said body. It is obvious that in every picture there are three substances to be considered from this point of view. In the first place there is the surface which is painted upon; this surface is usually either canvas or wood, especially in the case of earlier paintings; however many other materials have been experimented with by different artists at different times, including plaster, ivory, paper, leather, silk, china and pottery and even cobwebs. Secondly, there is the priming or sizing which is applied to the surface to prepare it for receiving the colors; thirdly, of course, there are the pigments employed by the artist.

Both wood and canvas, the principal surfaces to which oil paints are applied, are highly transparent to X-rays, but the former is more so than the latter, as might be expected. Different kinds of canvas vary likewise and one of our pictures represents a number of samples of different mesh.

The second element of the picture, the priming or sizing, is usually composed in the case of ancient pictures of carbonate of lime mixed with glue, and this composition has been found to be comparatively transparent to X-rays. Modern artists, however depend almost entirely upon the material known as ceruse (white lead), which is much more opaque in character and which, moreover, penetrates the interstices of the canvas upon which it is spread. Because of this fact the X-rays at once reveal a marked difference in this respect between canvases prepared with a modern priming and those employed by the artists of various centuries.

An even greater difference exists in most cases between the pigments to be found in many of the works of the old masters and those of which modern painters make use. While the ancients employed mineral colors almost exclusively those at the disposal of our modern artists include a number of colors derived from vegetable sources and others from the aniline group which, of course, were entirely unknown previous to the middle of the 19th century. The metallic paints used by the old masters are much more perceptible under the X-rays than

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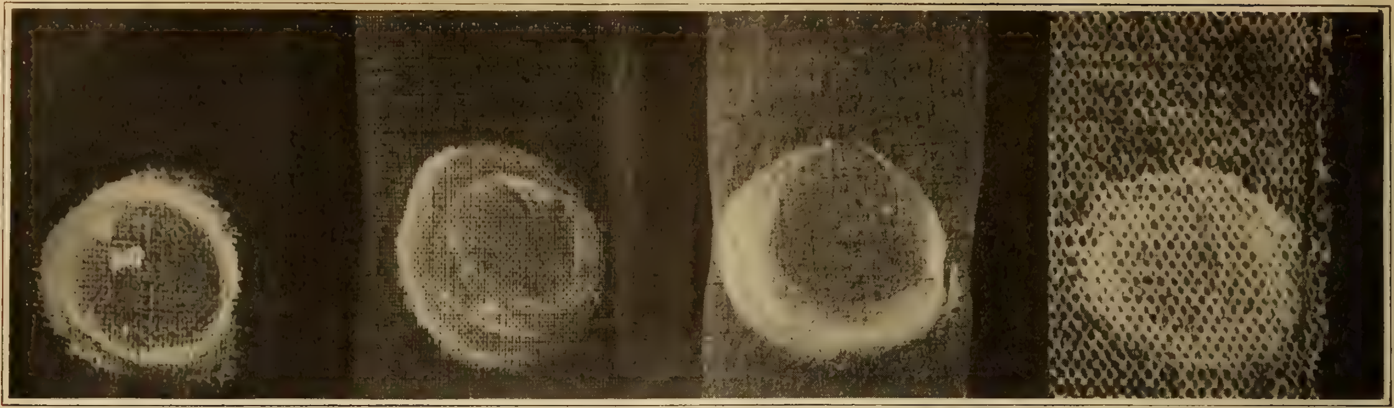
OPACITY OF VARIOUS PIGMENTS TO THE X-RAYS



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RADIOGRAPH OF STRIPS OF CANVAS SHOWING THEIR TRANSPARENCY TO X-RAYS

modern paints made of vegetable and aniline dyes.

As we have said, pigments vary greatly in their density and, consequently, in their degree of transparency to the X-rays. Some of them, like white, are now, and have always been, indeed, composed almost exclusively of heavy salts such as those of lead or zinc; hence they present a serious obstacle to the passage of the rays. Most of the blacks, on the other hand, including bitumen, which is much employed by painters for certain purposes, are extremely light and, therefore, readily allow the rays to pass. Between these two extremes we find a long series of the most various atomic weights among colors, from the very light carmine to the heavy chrome yellow, ranging through cobalt blue, ultra-marine, burnt sienna, Verona green, English vermillion and orange.

But a number of colors, as we remarked above, which were formerly composed of mineral salts, such as most of the reds for example, are frequently prepared nowadays from materials of plant origin, which are much more transparent, as is madder for example. The same thing is true of colors having an aniline base.

ESSENTIAL FACTORS IN OBTAINING A GOOD RADIOGRAPH

It is obvious that in order to obtain a satisfactory radiograph with comparatively clear outlines and a sufficient degree of contrast between the dark and the light areas two factors are all important. In the first place both the surface to be painted and the coating or sizing spread upon it before the pigments are applied must be transparent to the X-rays. Secondly the colors must be comparatively opaque, at least in the case of those whose contrasts form the images portrayed.

Luckily it is precisely these conditions which we find in the pictures of the old masters in general. Modern pictures on the other hand very commonly reverse these conditions since the sizing employed is comparatively opaque while the pigments are often considerably more transparent. Under these conditions the images produced will be more or less faint and indistinct — sometimes indeed they are so shadowy as to be almost invisible. The writer remembers seeing one such radiograph in which the canvas looked almost bare, though the picture it was made from represented a brilliant flower arrangement with effective contrasts of color and of light and shade.

It is for these reasons that radiographs throw a most valuable light upon the probable age of a picture, so that after devoting some study to their observation in the case of authentic paintings of a given era, or by the hand of a known

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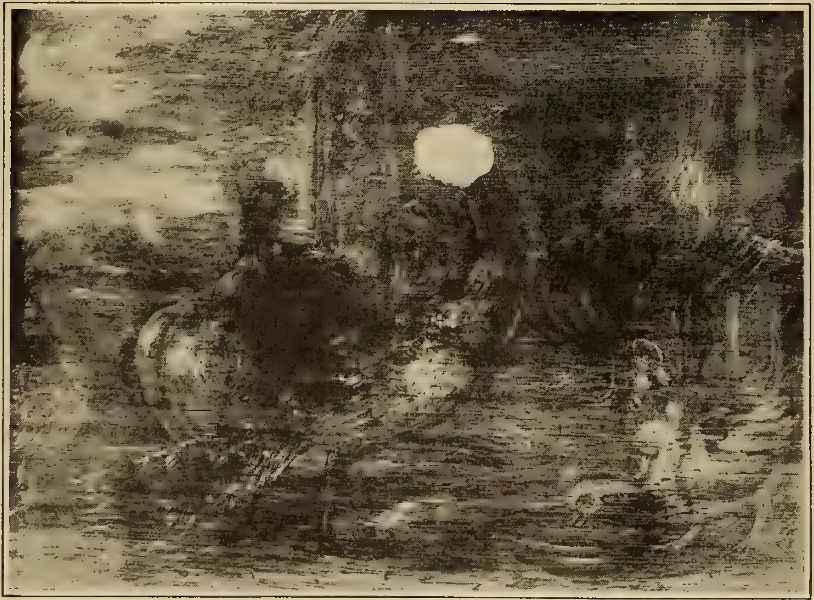
A FLEMISH SCENE ATTRIBUTED TO VAN OSTADE



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RADIOGRAPH OF THE ABOVE, SHOWING THAT IT WAS PAINTED IN MODERN COLORS OVER AN OLD PAINTING OF A BARNYARD SCENE

Note the two peacocks in the center foreground and the ducks at the right. The white spot is a lump of wax on the back of the picture. Above and below it may be seen very faintly two of the heads in the later picture.

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PHOTOGRAPH OF THE MADONNA OF THE STAR, A XVII CENTURY PAINTING, AND RADIOGRAPH SHOWING THE MARRED ORIGINAL AS IT MUST HAVE APPEARED BEFORE RESTORATION BY A MODERN ARTIST

painter, the connoisseur can readily detect modern "fakes," or rectify an honestly made mistake with regard to a picture wrongly attributed to a given school or master.

DETECTING EVIDENCE OF EARLIER RETOUCHING

But the radiograph does even more to assist in the correct appraisal of an old picture's value, since it reveals the ravages and defacements which it may have undergone from time to time during the centuries since its author laid down his brush, no matter how skilfully these have been concealed by the process known as retouching. The very fact that retouching is done at a later date than that of the picture's origin and usually by a different hand makes it highly probable that all the materials employed in the repair work, whether the pigments, the sizing, or the canvas itself, are of different manufacture and different atomic weight. When this is the case the repair work will show up in the radiograph in the form of spots of definite outline. Sometimes areas of a picture are discovered in this manner to be by a later hand though the presence of retouching had been absolutely unexpected until the magic rays revealed the evidence of early injury and skilful repair. Possibly some of our public museums and private owners will be none too anxious to submit their more doubtful treasures to the too penetrating vision of this modern mechanical detective of fraud, the X-ray tube. How painful to discover that a cherished Flemish or Italian masterpiece reputed of the 15th or 16th century in date was really the product of 20th century skill and fraud in some obscure studio of Paris, Antwerp or Berlin. On the other hand there is at least a possibility that a banal piece representing early Victorian taste, let us say, has been painted on top of a misprized masterpiece of earlier date.

An instance of fraud is illustrated on the opposite page. The picture in question shows a scene of festivity—a party of merry-makers playing upon musical instruments and dancing. The work is Flemish and was formerly attributed to Van Ostade. The radiograph made of this picture is very surprising and curious. The gay party of dancers have all vanished into thin air, except for the ghostly heads of two of them which can be dimly discerned in the middle of the image. In place of them we see upon the proof tolerably clear outlines of the figures in an entirely different painting—one of a barnyard scene which had evidently been previously painted upon the same panel of wood. The figures of two peacocks, two ducks, and a couple of chickens can be quite plainly seen. This barnyard scene is apparently quite old since there is no opaque sizing to disguise the outlines of the figures. The supposed or faked Van Ostade is probably modern since all its colors, except for the blues, are almost uniformly transparent to the X-rays.

Another interesting picture examined in this manner by Dr. Chéron not long ago is the picture of the Royal Infant at Prayer hanging in the Louvre Museum and ascribed to the French School of the 15th century. The curators of the collection had reason to believe from certain documents in their possession that the original background of the picture had suffered great deterioration and that this had been hidden or masked about a century ago by the application of the uniform black background seen in it at present. The radiograph taken by Dr. Chéron brilliantly confirmed this hypothesis. The black background proved perfectly transparent to the X-rays, revealing beneath it the badly damaged original background of a lighter tone.

The Madonna of the Star is also an admirable illustration of the effectiveness of the X-rays in revealing the outlines in an authentic picture of early date, the figures being quite clearly visible. Across the middle of the radiograph there is a band of white showing that the original must have been damaged at this point and restored by an artist using modern pigments. The radiograph also reveals deterioration at bottom of the picture which was restored in comparatively recent times.

Ancient Gem Engraving

The Engraved Gems of the Metropolitan Museum of Art

Reviewed by Albert A. Hopkins

THROUGH the courtesy of the assistant curator of the Department of Classical Art of the Metropolitan Museum of Art, Dr. Gisela M. A. Richter, we have received a "Catalogue of Engraved Gems of the Classical Style" beautifully illustrated with 88 plates comprising 463 figures. While the literature on engraved gems is extensive still this catalogue furnishes a worthy treatise in English on the subject, and is an excellent cicerone to the beautiful collection on Fifth Avenue.

The present catalogue deals only with gems of the classical style both intaglios and cameos, omitting the Oriental, Sassanian and Gnostic gems which have a different appeal. The eighteenth and nineteenth century gems of pseudo-classical style have been placed with the classical material, since their chief importance lies in their approximation to the classical style. The catalogue is divided chronologically into the chief periods of ancient art, and within these chronological divisions it arranges the gems according to subjects. Each section is preceded by a short historical note showing the influence of contemporary events on the art of gem engraving.

EIGHTEENTH CENTURY ENGRAVER AT WORK
From Mariette's Pierres Gravés

A collection of ancient gems satisfies our æsthetic sense in many ways. The inherent beauty of the material, with its rich and varied colors, its luster and brilliance, gives us pleasure at first sight. The hard and durable quality of the stones has made for unusually good preservation, so that we can appreciate in many cases the artist's work in its original state—a rare opportunity in classical art. Moreover, the smallness and preciousness of the gems invited exquisite workmanship, and in certain periods when the art was at a high level the achievements in this field were very notable. The best ancient gem engravers combined extreme minuteness and accuracy of detail with a largeness and simplicity of style that are indeed remarkable. A gem engraving of this class possesses the nobility and dignity of a marble or bronze sculptural work, though it is often confined to the space of less than half an inch square.

This quality of combining minute size and exquisite finish with grandeur of effect lifts these gems out of the class of decorative objects and puts them on a par with the products of the higher arts. And yet, though the best ancient engravers could give this sculptural quality to their work, they kept strictly to the technique of their own trade. They showed great skill in the treatment of the intaglio relief, observing—at least in the best periods—a certain uniformity of surface and avoiding excessive projections. The compositions are cleverly designed for the field they occupy, falling easily within the prescribed limits without any feeling of restraint or confinement. And this applies not only to single figures in all manner of poses but to the not infrequent groups; for even where several figures are introduced or various objects related to the scene are added, there is rarely a sense of crowding—so perfectly is the design suited to the space.

Not only do classical gems follow closely the prevalent styles of their periods, but the choice of subjects represented on them is equally inclusive. These subjects comprise, in fact, the mythology and the daily life of the Greeks, the two great themes of classical art. Thus, in a representative collection of gems we can pass in review almost every Greek god, goddess, and hero, as well as many subjects of everyday life, especially portraits and animals. And, since this is the case for so extended a period, we have here an exceptionally comprehensive picture of the development of classical types. We shall find that, varied as the subjects on the gems are, they teach us again the lesson we learn in our contact with all Greek and Roman art—that the classical mind preferred to adopt certain types and repeat these, of course with infinite variations, rather than try to produce continually fresh models and themes. This adherence to certain standardized types makes the ancient work, even when carelessly executed, usually fine in composition and space filling, and, viewed as a whole, it impresses us with that sense of vitality controlled by order and purpose which is so prominent a characteristic of classical art.

In order to understand fully the representations on gems, we must bear in mind another important characteristic of classical art—its symbolism. By this we do not mean an abstruse symbolism to express abstract ideas, by which some moderns still delight to interpret Greek art—for that is essentially un-Hellenic; but a perfectly obvious symbolism, by which a flower stands for a flowery meadow, waves for the sea, a chair for an indoor scene, a column for a house; in other words, by which a small concrete part stands for the concrete whole. We are familiar with such a shorthand method of expression even in Greek vase paintings; its advantage in the restricted space of a gem is apparent.

GEMS AS SEALS

Besides their artistic and historical value, classical gems make a strong appeal to us through their intimate relation to the personal lives of the Greeks and Romans. Their primary object was to serve as seals, and seals in the ancient world played a very important rôle. They took the place of Yale keys and combination locks; for the Greek and Roman householder would guard against the infidelity of his slaves by placing his seal on the doors of chambers and closets in which he kept his jewelry, his secret papers, his supplies, and

other precious belongings. Many ancient sealings of all periods have been found, chiefly of clay, and the ancient writers often refer to this practice. In the Thesmophoriazusae of Aristophanes, for instance, the women complain that the stores of meal, oil, and wine are guarded too well by

ENGRAVED GEMS IN THE METROPOLITAN MUSEUM OF ART

1. Rock Crystal Ringstone of Serapis—Hellenistic Period. 2. Carnelian Ringstone Head of Asklepios Graeco-Roman Period. 3. Girl Dancing Gold Finger Ring. Developed Greek Style. 4. Carnelian Ringstone of a Sculptor. Italic, First Century B. C. 5. Banded Agate Showing a Crane. Developed Greek Style. 6. Herakles—Archaic Greek Period

their husbands' seals; and Isokrates is shocked by the action of Pythodoros, who opened the voting urns, "sealed by the Prytanes and countersealed by each of the Choregoi." Again, Horace describes an amiable neighbor who is kind to his slaves and "does not go mad when the seal of his wine jar is broken."

Furthermore, the seal in the ancient world corresponded to a written signature today. At a time when the large majority of people were unable to write and had to depend on the services of the professional scribe, the impression of a personal seal was the only reliable identification mark. And in the days before the handling of mail by a government postal service, such identification marks were doubly necessary, for all correspondence had to be entrusted to private carriers who might or might not be trustworthy.

The danger of having one's seal fall into the wrong hands was naturally great, and could entail serious consequences. The story of Hannibal's appropriating the seal of the Roman general, Marcellus, and almost capturing a town in consequence is well known (cf. Livy, XXVII, 28). To forestall such deceptions it was best to have one's seal in safe-keeping before death, and either to destroy it, or to give it to a trusted friend, as Alexander did to Perdiccas (Quintus Curtius, X, v, 12, and Aemilius Probus, In Eumenen, II, 1), and Augustus to Agrippa (Dio Cassius, LIII, 30). If one had no such trusted friend, one's position was difficult. Suetonius tells that Tiberius on his deathbed pulled off his ring to give it to a bystander and after some hesitation replaced it on his finger (Suetonius, Tiberius LXXIII, 2).

CHOICE OF DESIGNS ON GEMS

In the choice of designs for seals we have seen that the ancients drew from the prevalent artistic stock. It would have been an alien thought to a Greek or Roman to use for his device merely his monogram, as we might nowadays. His name or initials might appear occasionally on the gem in a secondary place; but the principal design would be pictorial. And yet, though the selection was made from the general store, there must often have been a special appropriateness in the chosen device, as in the family crests or the individual book-plates of today. The choice was apparently oftenest a favorite deity, or mythological hero, or animal, or symbol: sometimes it commemorated a glorious event in the family or a personal deed of valor, or it was the portrait of an ancestor, or friend, or leader. Often, again, there would be no special relevancy—but the design would be a beautiful composition that appealed to individual taste. It is, indeed, just this element of individuality which differentiates the gems from other classical monuments and gives them much of their charm: they are not only the precious possessions of individuals employed by them for their own particular uses, but they were in most cases probably specially made for these individuals and so express their personal choice.

An engraved gem used for an official purpose is very near in character to a coin; for coins are the public counterpart, so to speak, of gems; they bear the seal of the state, while gems bear the seal of the individual. Naturally the connection between these two types of monuments must have been close, since they presented similar problems to their makers. Often we find the same motives on the coins and gems of one period; but the gems which represent individual taste show a much greater variety of subject than the coins which bear the emblems of cities. Doubtless the Greek mints were a constant source of inspiration to the gem engravers, and it is probable that sometimes the same man was master of both arts.

Besides serving the practical purpose of sealing, engraved gems were often used by the ancients merely as ornaments, the combination of a precious material and an artistic representation making such a use singularly appropriate. The varied colors and the glitter of the stones were, of course, to many attraction enough, so that unengraved stones were employed much more generally for this purpose than the engraved ones. But we can imagine that, to the discriminating at least, the

FRAGMENT OF A LARGE ONYX CAMEO OF THE GRAECO-ROMAN PERIOD

pleasure in a beautiful engraving far outweighed the more primitive delight derived from sparkling stones.

GEMS AS AMULETS

In addition to serving as seals and as ornaments, gems in ancient times played an important rôle as objects supposed to have curative and protective power. Even nowadays the belief in the magical properties of certain stones is still preva-

lent with many people; so that we can easily understand how in a less scientific age such ideas were both widespread and deep-rooted. We have abundant evidence for this both for Greek and Roman times. Aristophanes speaks of the "medicinal ring" which druggists evidently sold cheap to their clients in the place of drugs. Such rings, we are told, could avert the evil eye and guard against snakes. The learned Pliny in the thirty-sixth and thirty-seventh books of his Natural History quite seriously gives us a long account of the magical properties of stones.

The diamond, he says, cures insanity and vain fears and prevents poisons from harming; the amethyst prevents drunkenness; if engraved with the name of the sun or moon and hung around the neck with hairs of a cynocephalus or with swallow's feathers, it is an antidote for poisons, gives right of access to kings, and averts hail and locusts. An emerald engraved with an eagle does the same; a certain kind of agate is beneficial against bites of spider and scorpion. Hematite is good for the eyes and liver, gains requests addressed to kings and is useful in lawsuits; mixed with juice of pomegranate it cures those who vomit blood. Sideritis increases anger between parties to a lawsuit and so on, through a long list. There certainly were compensations in an unscientific age when you could believe such entertaining things.

THE TECHNIQUE OF GEM ENGRAVING

Only soft stones and metals can be worked free hand with cutting tools; the harder stones require the wheel technique. This technique was known to the Minoans, who learned it perhaps from the Babylonians, by whom it was practised at least as early as 1,500 B. C. The method of work of the ancients seems to have been very similar to that in use today, to judge by the references we have to this work in classical literature, by an examination of the stones themselves, and by the scanty evidence of actual representations of gem engravers. By this method the stones are worked with variously shaped drills which are made to rotate by the help of the wheel. The cutting is not done by the drills, which are of comparatively soft metal (they are now of iron, not steel, and in Mycenaean times at least must have been of bronze or copper), but by the powder which is rubbed into the stone with the drill. This is nowadays the diamond powder mixed with oil. What it was in ancient times is not certain, as we do not know how early the diamond became known. It was certainly familiar to the Romans, as it is mentioned both by Pliny and by M. Manilius. The type of wheel used in our times is either one worked by the foot or by an electric motor lathe. The former, though more cumbrous, has the advantage of giving the artist more direct control over the speed. On a gravestone of a gem cutter of the Roman Empire found at Philadelphia in Asia Minor, a tool is represented which looks like the bow used by modern jewelers. This, by being drawn quickly back and forth, could impart a rotating movement similar to that of the wheel. But since we know that the wheel was well known to the ancients, in the making of pottery, for instance, it is certainly probable that they made use of it in gem engraving also.

Nowadays the stone to be engraved is fastened to a handle and held to the head of the rotating drill and moved as the work requires. It has been suggested that the ancients reversed the process and held the stone stationary while the rotating tools were guided by the hand, as in modern dentistry. There is no means of settling this point, which in itself is unimportant.

The shapes of the tools must have been essentially the same as those in use today, ending in balls, disks, cylinders, etc., in all sizes ranging from about a quarter of an inch to a pin point.

It is a debatable question how much the diamond point was used in ancient times for fine detail lines. It was apparently used hardly at all in the earlier Greek period, but on Hellenistic and Roman gems we occasionally find fine lines with sharp edges which could only have been made by such means. The lines produced by the help of the wheel would always have round edges. The passage in Pliny, which speaks of small diamond particles "ferro includuntur" has been interpreted as referring to the use of the diamond point; but Pliny's account is so general that it may refer simply to engraving with diamond powder. The modern gem engravers never use the diamond point.

After the cutting of the gem was complete the surface was often polished. In pre-Hellenic gems the engraving was either left dull or the polish was confined to the larger surfaces. Etruscan scarabs, on the other hand, show a high polish, even when the work itself is careless. Beginning with the Hellenistic period and throughout the Graeco-Roman times the more carefully worked gems show a detailed and often high polish. Nowadays for outside polish engravers use very fine diamond powder and oil applied on a very hard wooden tool (generally boxwood). For the inside polish tripoli powder mixed with water is used on a copper tool or on a stiff brush made to rotate on the wheel. The ancients appear to have used Naxian stone (maximum) for this purpose, to judge from a statement by Pliny.

MATERIALS USED FOR ANCIENT GEMS

The favorite materials employed by the Greeks and Romans for their gems were at all times the colored quartzes. These had the advantage of being easily worked on the wheel and still being hard enough for general use; moreover, they came in beautiful colors and could be finely polished. Especially popular were the chalcedonies or non-crystallizing quartzes. Besides the quartzes, the ancients also used harder, more precious stones, as well as a few inferior varieties and glass pastes.

These were principally Carnelian, Sard, Chalcedony, Plasma, Jasper, Agate, Rock Crystal, Amethyst, Garnet, Emerald, Aquamarine, Topaz, Peridot, Moonstone, Sapphire, and Turquoise, while Lapis Lazuli and Malachite were sparingly used. The inferior varieties were Hematite, Steatite, Serpentine and Porphyry. Glass pastes were used as cheap substitutes.

COTTON DYEING—PAST AND PRESENT

PROFESSOR L. A. OLNEY, in the *American Dyestuffs Reporter*, gives an historical outline of the science of dyeing, the development of union colors, classification of coal-tar dyes, sulphur colors, Turkey red and Para red, vat dyeing and some reference to dyeing machinery, all of which are contained in a short article which will be of interest to any seeking to be better informed upon this important subject. In view of the increase in the usage of dyeing terms, the following quotation is made from the article in question:

"The coal-tar dyes may be classified in several different ways, but for the use of the practical dyer there is but one satisfactory method, namely, that which divides them according to their action upon the different fibers; in other words, according to their methods of application. This classification recognizes ten groups as indicated in the following table. The fibers to which these dyes are applicable are also indicated in each case, and their most important uses in *italic* type. A blank line indicates that dyes are either not used at all or their application is too limited to be of consequence.

Class of Dye.	Fibers upon Which They are Applicable		
1. Basic dyes	*Cotton*	Wool	Silk
2. Eosins and related dyes	Cotton	Wool	*Silk*
3. Acid dyes	......	*Wool*	Silk
4. Direct cotton colors	*Cotton*	Wool	Silk
5. Sulphur dyes	*Cotton*	.....	....
6. Mordant dyes	Cotton	*Wool*	Silk
7. Mordant acid dyes (after chrome colors)	......	*Wool*	Silk
8. Insoluble azo dyes	*Cotton*	.....	....
9. Reduction vat dyes	*Cotton*	Wool	Silk
10. Aniline black	*Cotton*	.....	....

Fireproofing Fabrics*

Treatment of Sack Materials, Tent Cloths and Balloon Fabrics

By W. Hacker

THE methods used in fireproofing various fabrics consist in impregnating the fibers with solutions of different chemicals or in covering them with coatings which either evaporate or melt in the heat. Complete non-inflammability cannot of course be obtained as long as the fibers themselves are of an organic origin. The chemicals, which are used most generally for this purpose, are the easily fusible borates, phosphates, stannates (tin salts), tungstates, molybdates and titanates. Frequently, ammonium salts are also added.

Of all the various substances which can be used to fireproof fabrics, the most important and most efficient are ammonium sulphate and ammonium phosphate. While borax, boric acid, water glass, aluminum salts, stannates, tungstates, or the salts used for wood impregnation, iron, copper or zinc sulphate solutions, mixed with calcium or barium chloride, are all very useful and valuable, none of them can surpass the ammonium salts in the effectiveness of its action.

The technology of the fireproofing of textiles and other combustibles has been discussed in great detail by P. Lochtin in *Dingler's Journal*, Vol. 290, p. 230. A great many salts are described and classified according to their action in this respect, that is, whether they promote, hinder or are indifferent to the propagation of the combustion phenomenon in combustible materials. It was found that the following salts render cellulose non-inflammable, viz.: ammonium phosphate, ammonium sulphate, sal ammoniac (NH_4Cl), the chlorides of calcium, magnesium and zinc, tin sulphate, tin salts in general, alum, borax, boric acid and aluminum hydrate.

THE SILICATES AS FIREPROOFING AGENTS

Lead orthosilicate ($Pb_2S_1O_4$) was used for the first time by Abel in fireproofing textile fabrics. A mixture of glycerin and asbestos or graphite is used to coat fabrics so as to render them fire-resistant. The fiber is soaked in a linseed oil varnish either before or after being treated with the glycerin mixture and is finally painted with an oil color. (German patent 102,314.) Another method is to apply an undercoat of a composition, consisting of kieselguhr, chalk and linseed oil and a top coat of a molten mixture of water-glass, calcium chloride and common salt (German patent No. 108,723).

A Swedish patent (No. 25312, 1907) has been issued on a method of fireproofing fabrics by impregnating them with a concentrated solution of alum, which is mixed with potash, common salt and a suspended solution of turpentine and asbestos in muriatic acid. Before using, the mixture is diluted with twice its weight of water and mixed with a little flour and water glass. A mixture of sodium silicate and soap together with small amounts of glycerin, sodium tungstate and oleic acid, saponified by means of calcium carbonate, is also used according to British patent No. 717, 1909.

BORAX AND AMMONIUM SALTS

Very good results have been obtained with the use of these salts in conjunction with other substances. As an example, 80 kg. of aluminum sulphate, 25 kg. of sal ammoniac, 30 kg. of boric acid, 17.5 kg. of borax and 25 kg. of starch are dissolved in 1,000 liters of water. Separate solutions of 50 kg. of alum or ammonium phosphate, or 150 kg. of borax and 110 kg. of magnesium sulphate are also advocated, each solution being used in succession. Another mixture consists of 20 kg. of borax, 60 kg. of alum and 10 kg. of sodium tungstate. It is best to impregnate the cloth with the phosphate solution first, then to treat it with a dilute solution of ammonia, containing magnesium chloride and finally to wash it with very dilute ammonia. English patent No. 15382, 1887, advocates the use of calcium chloride and ammonium phosphate. Still another method is to impregnate the fabric with an aqueous solution of calcium ammonium salts, then to apply a solution of soda and to paint it with a mixture, containing alumina, talc, kaolin and colored varnish, ground in alcohol.

A very effective fireproofing composition, patented in Norway (No. 17803, 1906) consists of 5 to 15 parts of phosphate and 85 to 95 parts of tungstate (50 to 75 parts of phosphate-tungstate can also be used) in one liter of water. The impregnated material is washed thoroughly and the process is repeated. An aqueous solution of equal parts of calcium acetate and calcium chloride has also been used for this purpose.

In the *Seifenseider Zeitung*, 1911, page 955, there is described a method of fireproofing fabrics by the use of a mixture, consisting of one kilogram each of sodium hyposulphate, maize starch, common salt, talc and 500 grams of borax. The materials are dipped for 2 to 3 minutes into the lukewarm pasty mass and then dried. French patent No. 456589 describes a method for fireproofing fabrics of all sorts by immersing them first in a 65 per cent solution of alum, then drying and submerging them in a 50 per cent ammonia sulphate solution, wherein they are allowed to remain over night. They are then dried slowly. A novel process for rendering textiles resistant to heat is revealed in U. S. Patent No. 1048912, wherein a caoutchouc solution containing ground mica and pulverized asbestos, is used.

FIREPROOFING COTTON FABRICS. "NON-FLAM"

It is often necessary to wash fabrics and it is desirable that they do not lose their fire-resistant properties after they are washed. W. H. Perklin has invented a process of treating flannel so that it is possible to wash the goods without any danger of their becoming inflammable again. This is done by steeping the pieces of flannel completely in a 45° Tw. solution of sodium zincate. The excess solution is squeezed out and the material is dried in copper drums. When the cloth is thoroughly dry, it is impregnated with a 15° Tw. solution of ammonium sulphate, pressed again and dried once more. The cloth is then washed to remove the sodium sulphate, whereat it is dried for the third time and is then ready for use. It has been established by means of numerous tests that the colors in the flannel are not injured in any way; that the insoluble tin salts precipitated on the fiber do not attack the skin; that the tensile strength of the flannel is increased about 20 per cent and that the non-inflammability of the treated fabric remains intact after 25 washings by hand and 35 washings with a washing machine. This cloth is known as "Non-Flam" in the trade.

USE OF STANNATES

According to German patent No. 150465, a 22° Bé. solution of sodium stannate is used to impregnate fibers to render them fireproof. The material is dried after this treatment and then passed through a 16° Bé. solution of zinc acetate. It is well to wash the size out of the cloth before putting it through the fireproofing process. Furthermore, the material is generally soaked in olein, soap or glycerin after being washed, which renders the action of the metallic salts more effective.

In a similar manner, wood, paper or textile fabrics can be made fire-resistant (German Patent No. 151641) by passing them through a bath of sodium stannate after a preliminary washing (sp. gr., 1.04 to 1.08) and then through another bath,

*Translated for the *Scientific American Monthly* from *Kunstoffe*, 61-4, 1920.

containing 33 per cent titanium sodium sulphate and 7.5 per cent of ammonium sulphate. The last step is to draw the cloth through a solution of water glass (sp. gr. 1.1). Then it is washed and sized in the usual way. It is not necessary to use the stannate solution as the cloth is rendered sufficiently fire-resistant by treatment with the titanium salt alone.

CASEIN COATINGS—ELECTRICAL WIRINGS

When fabrics, wood and other similar materials are coated with casein containing compositions, they are made fireproof as well as waterproof. German Patent No. 220860 describes such a pasty mixture, containing 10 parts of zinc oxide, 10 parts of water and the necessary coloring matter, combined with a solution of 10 parts of casein, 10 parts of ammonia and 10 parts of ammonium bromide in 30 parts of water. This composition carbonizes rather readily, when an attempt is made to ignite it, but it does not burn. It is particularly well suited for impregnating the fabrics used in covering electrical conductors.

TREATMENT OF JUTE

Jute can be sized and made waterproof at one and the same time by the following process (see *Technisches Rundschau*, 1913, 313). The first step is to steep it in a 3° Bé. solution of acetate of aluminum and then to dry it at 50 to 60° C. The treatment is repeated twice and then the jute is sized either in a solution containing 90 grams of protamol, 5 grams of glycerin, 15 grams of vaseline and 100 ccm. of a 3° Bé. solution of aluminum acetate in 790 ccm. of water, or with a mixture of 90 grams of protamol, 30 grams of magnesium sulphate, 5 grams of glycerin and 15 grams of vaseline in 860 grams of water.

Jute and other coarse meshed fabrics can be waterproofed by impregnation with an emulsion of 10 parts of asphalt and 10 parts of cellulose, 5 parts of glue, 1 part of chrome alum, 8 parts of tar oil, 16 parts of benzol and 50 parts of water. For waterproofing linen, used to make sails, H. Jennings recommends the use of zinc soap.

COTTON SAIL CLOTH

The first step in the process of waterproofing cotton sail cloth is to remove the sizing by treatment with wort (malt extract) or caustic potash solution. The cloth is then hung up to dry in a drying loft and further impregnated with a clear 5° Bé. solution of alum at 30° C., made by dissolving 30 kg. of alum in 180 liters of boiling water, which contains 12½ kg. of calcium pyrolignite. After 2 to 3 immersions, the cloth is dried at 40 to 45° C. and, after the vapors of acetic acid have been removed, it is fixed by six successive immersions in a solution of 500 grams of 66 per cent water glass in 150 liters of water, maintained at the boiling point.

WATERPROOFING TENT AND AWNING CLOTH

The waterproofing process consists in painting the cloth with a solution of 2 kg. of alum, 1 kg. of isinglass and 0.5 kg. of white soap in 50 liters of water and then applying a coating, consisting of a water solution of 2 kg. of lead acetate in 50 liters of water. In this way a completely insoluble lead soap is formed in the pores of the cloth, closing them up entirely. (For further details see *Farbe und Lack*, 1912, 24.)

WATERPROOFING SAIL OR TENT LINEN

According to German Patent No. 187027, the waterproofing composition is made as follows. One part of a solution of asphalt in coal tar is cooked for five minutes with 1.5 parts of spirit varnish containing lampblack (black varnish), 2.5 parts of wood tar and 2.5 parts of coal tar. One part of varnish and one part of airproof varnish are added to the cooled mass. The latter is made by dissolving 33 grams of white shellac and 750 grams of sandarac (or realgar, a type of resin, resembling mastic very closely) in 2,000 grams of 95 per cent alcohol and 500 grams of venetian turpentine. This absolutely permanent preparation is painted on both sides of the linen cloth in as thin a coat as possible and is rubbed into the material by means of a hard brush.

Calcium acetate and sulphate of aluminum are used to render linen impervious to water. (For details, see *Oesterr. Woll. u. Lein. Ind.*, 1907, 1379).

An easy method of waterproofing sail cloth (linen) consists in steeping the linen in a 7 per cent gelatine or glue solution, warmed to 40° C. After the cloth is air-dried the gelatinous coating is hardened by means of a 4 per cent solution of alum. The cloth is dried again and washed with pure water. (*Techn. Rundschau*, 1911, 311.)

AGGLUTINANT FOR SAIL LINEN OR WAGON COVERINGS

In the *Seifus Zeitung*, 1911, 314, there is described an adhesive which can be used on sail linen and the coverings for wagons and which consists of 18 parts of gutta-percha, cut up in fine pieces, dissolved in 20 parts of carbon disulphide, 10 parts of benzol and 10 parts of turpentine. After several days, especially if the mixture is heated slightly, complete solution takes place. Then 42 parts of finely powdered asphalt or rosin are dissolved in the solution and the adhesive is ready for use. According to another recipe, 15 parts of finely cut up gutta-percha are dissolved in 45 parts of warm turpentine, benzol or carbon disulphide and 40 parts of a quick drying varnish, mixed with about 10 per cent of manganese drier, are added.

IMPREGNATION OF COARSE FIBERS

A mixture suitable for this purpose consists of 15 liters of boiled linseed oil, 5.5 kg. of pine soot, 0.5 kg. of yellow wax and 0.5 liter of rapid drying oil. After drying, it is covered with a similar mixture; finally the mixture is allowed to dry slowly for four weeks at the room temperature.

Tubes and pipes, made out of sail cloth, can be impregnated with a mixture, consisting of boiled linseed oil varnish, which is obtained by careful heating of raw linseed oil to 150° C. and several hours' cooking at 220 to 230° C. After cooling to 150° C. an addition of 3 to 4 per cent of lead resinate or lead manganese resinate is made.

FIRE HOSE MADE OF SAIL CLOTH

The inside of fire hose made from sail cloth and used under moderately high water pressure is impregnated with a mixture of 11 liters of linseed oil, boiled with 130 grams of ground litharge and 130 grams of umber. (H. Brand in *Farbe und Lack*, 1912, 16). After heating for 24 hours (this must not be done over the open fire), the mixture is ready for use. Two coats are applied as a rule.

A solution of an aluminum soap in turpentine can also be used for this purpose. Instead of painting the hose, the dipping process can be used as well. Another method of treatment consists in an initial immersion in a soap solution and then in a solution of a metallic salt, whereat a water-insoluble metallic soap is precipitated in the pores of the fabric. The first solution, according to *Farbe und Lack*, 1912, 32, contains 4 kg. of alum, 2 kg. of isinglass and 1 kg. of white soap, dissolved in 100 liters of water. The second solution is made by dissolving 2 kg. of lead acetate in 50 liters of water. To dry the coating and to prevent the soap from becoming sticky, a current of cold air is blown through the hose.

TREATMENT OF HEMP FIRE HOSE

Hemp hose, which is to be used at pressures up to 10 atmospheres, must be treated so as to be watertight and also to prevent rotting of the fabric. For this purpose, a tannin solution is used to impregnate the fiber and an inner coating of a solution of gum is applied.

TREATMENT OF BALLOON AND AEROPLANE CLOTH

The fireproofing of balloon and aeroplane cloth is described in *Kunstoffe*, 1913, 438 (see also the work by A. Rost, entitled "A New Use for Cotton"). The manufacture of gas-tight and

water-tight balloon fabrics is covered in British Patent No. 2064-1911. The fabric is made of several layers of goldbeater's skin, cemented together with a gelatine solution and impregnated on both sides with a solution, containing 5 parts of collodion, 5 parts of castor oil and 10 parts of amyl acetate dissolved in 100 parts of an acetone-celluloid solution. The treated fabric is then provided with a layer of silk or wool on one or both sides.

Good results have been obtained by the use of the following mixture, from the standpoint of gaseous impermeability of the fabric. The mixture contains 4 kg. of Para rubber, 30 grams of paraffine (melting at 66° C.), 400 grams of sulphur and 170 grams of magnesium oxide. This preparation is suitable for cloth to be vulcanized at an elevated temperature, while for vulcanization in the cold, the mixture need contain only 4 kg. of Para rubber and 50 parts of paraffine. The tensile strength of the fiber can be increased by impregnation with a mixture of 4 kg. of Para rubber, 40 grams of paraffine, 2.6 kgs. of magnesium carbonate, 360 grams of magnesium oxide and 400 grams of finely powdered sulphur.

According to French Patents Nos. 427818 and 14044, absolute impermeability is obtained by treating balloon fabrics with a varnish, containing a solution of acetyl cellulose and some caoutchouc in tetrachlor-ethane together with an alcoholic solution of a dyestuff.

A newer process of treating balloon fabrics consists in gumming them on the inner side and dusting them with powdered cork. The entire cloth is then cemented fast together by vulcanization. In this way several distinct advantages are gained. In the first place, the layer of cork increases the impermeability of the shell of the balloon, reducing thereby the loss in gas. Then, rapid changes in temperature within the gaseous volume of the balloon are avoided because of the low heat conductivity of the cork covering. Finally, the chemical action of the gases on the material of the balloon is averted. This last fact is of considerable importance, although it has been given scarcely any attention at all.

F. Frank mentions in *Gummiztg*, 1912, 801, that copper and iron have the most deleterious action on balloon materials, as they act as catalysts even in the minutest quantities and cause the formation of acids by the reaction between the sulphur, used in vulcanization, and the oxygen of the air. The best measures of prevention are to paint the fabric with a preventive paint and to impregnate the material with indifferent dyestuffs and metals.

According to German Patent No. 262005 after the balloon cloth is impregnated with a liquid, containing oil, it is covered with "syndeticon" and the sticky fabric is dusted with metallic powder. An impregnating solution, consisting of celluloid dissolved in amyl acetate and admixed with castor oil and wax, is described in German Patent No. 266384.

MANUFACTURE OF WATERPROOF CLOTHING

An article in *Seifens. Ztg.*, 1911, 1177, details the manufacture of waterproof clothing by immensing the cloth in a dilute solution of glue in the first place, which contains about 10 to 20 per cent of linseed oil varnish. Then, after drying, the fabric is impregnated with a decoction of linseed oil varnish with 10 per cent of manganese drier. The elastic properties of the mass can be increased by the addition of 5 per cent of paraffine. Another method consists in impregnation with a mixture of 60 parts of a 15 per cent caoutchouc solution and 40 parts of linseed oil varnish. For dark cloth, a solution containing 15 parts of hard asphalt and 5 parts of paraffine, all mixed with 15 parts of asphalt tar, 10 parts of rosin oil and 30 parts of linseed oil varnish in 25 parts of benzol can be used. Oiled cloth, which has become sticky, must be rubbed with turpentine or benzine until the stickiness has disappeared. After several days, the cloth is varnished.

German Patent No. 65349 describes a method of avoiding stickiness in the oiled coating by coating the cloth with a mixture of linseed oil varnish, petroleum ether, litharge and ammonia.

THE PROGRESS OF CHEMICAL RESEARCH IN TEXTILE FIBERS

Extracts from the annual reports of the Society of Chemical Industry on the subject of chemical research in textile fibers appear in the October issue of the *Color Trade Journal.*

These abstracts show the work divided into cotton, wool, silk, artificial silk, paper yarns, balloon and airplane fabrics, flax, hemp and miscellaneous fibers.

Notwithstanding the large amount of work being done on cotton materials much of the work continues to be applied to yarns and cloth and far too little of it to the ultimate cotton fiber upon which all else depends. One investigator has found that considerable improvement in physical properties such as elasticity, may be obtained by treating the cotton yarns with a solution of caustic soda to dilute for mercerizing. Another finds that mercerizing with, or without, tension tends to increase yarn strength but with a decrease in fiber strength. This latter investigator believes that processes up to the stage of spun yarn have no detrimental effect on the individual fibers. A number of valuable papers have appeared on the subject of purifying cotton and the effect of such an extraction agent as benzol, alcohol, water, ammonia, formic acid, hydrochloride acid, lime and caustic soda, has been examined with special reference to the nitrogen content of the fiber. The total extract amounts to about 4 per cent, and nitrogen from .2 to .26 per cent of the weight of the yarn. Boiling with lime or soap removes less than 50 per cent of the nitrogen present but no other single treatment was so successful as the caustic soda which removes 80 per cent.

On wool, investigations continue into the influence of atmospheric moisture on electrical phenomena and the most suitable conditions for drawing and spinning. In the case of worsted, the degrees of humidity were 77 per cent for drawing, and 50 per cent for spinning. The effect of dry heat on wool has been examined with result that the fall in strength even at 150°C. is only about 3 per cent, but at higher temperatures the sulphur naturally in the wool becomes oxidized to sulphate and in the presence of moisture causes rapid decomposition.

Scouring continues to be a live topic for research including the absorption of soap by the wool in aqueous solutions. It has been found that from 3 to 6 per cent of fatty acid may be absorbed by cross-bred serge, and that the cloth may retain from .4 to nearly 1 per cent even after boiling in water.

The resistance of wool to weather has previously been discussed and it will be recalled that fiber treated with chromium salts is much more resistant to the destroying action of the weather.

Most of the work in silk has to do with boiling off processes, the possibility of using enzymes to destroy the natural silk gum and the question of grading and classifying raw silks. Notwithstanding the increasing popularity of artificial silk, there appears to be less and less literature concerning it excepting in an occasional item on distinguishing natural from artificial silk.

The use of paper yarns for clothing textiles in Germany has lessened with the appearance of cotton as was to be expected. In Japan interest is being shown in the possibility of weaving paper with hemp, silk, and cotton fibers. "Oriental Panama" is of Japanese origin and is produced by coating twisted papers with solutions of nitro cellulose or nitro celluloid.

Balloon and airplane fabrics continue to hold interest and involve the development of tests for such fabrics, methods of determining their probable rate of deterioration in advance, and permeability to various types of gases, methods for rendering them rainproof and ways of using cotton fabric to substitute for linen fabrics on wings.

Under flax, hemp, and miscellaneous fibers may be mentioned researches designed to produce improved strains of flax and investigations into the problem of retting. It appears that the principal agent which retards bacterial retting is acidity which is constantly removed when flax is retted in running water. Based upon this a process has been intro-

duced using a caustic alkaline bath which is tempered by the presence of organic matter such as the acid waste liquor from previous operations.

THE RESISTANCE OF TEXTILE FIBERS TO HIGH TEMPERATURES

In the *Color Trade Journal* for November there is a note on the resistance of silk and linen to high temperatures and to ultra-violet rays. The work in question was done by M. Leo Vignon who exposed lightly stretched fabrics during June and July to such influences as solar light, dry heat, moist heat, moisture, obscurity, and the ultra-violet rays.

The results obtained indicate that the fabric of animal origin is more resistant to high temperatures and to ultra-violet rays than that of vegetable origin and the differences measured are thought to be due to the fact that the albuminoid molecule is more resistant to hydrolysis than the cellulose molecule. This explanation is in accordance with views previously held concerning the facility with which cellulose gives modified products, such as hydrocellulose and oxycellulose, whereas the animal fibers do not yield analogous products.

DETERMINING THE DEGREE OF SWEETNESS IN ARTIFICIAL SWEETENERS

Since artificial "sweeteners" (saccharin and dulcin) have become increasingly important from the economic viewpoint, a greater degree of attention deserves to be paid to the methods for determining the sweetening powers of these substitutes for sugar, since upon this their correct value and usefulness obviously depend. Measurements of this sort were long ago attempted but all authorities well know that up to the present there has been considerable uncertainty in this respect and that, at any rate, a generally known and practically applicable method has been lacking, and yet such a process is attainable by means of experimental psychology. The method in question being known as the "constancy" method which applies to stimuli of apparently equal effect, the stimuli, in this case being various degrees of concentration; this method yields results according to a definite formula equation (by Spearman-Wirth) of the stimulus value sought, *i.e.*, the sweetening power. The essential features of the process are as follows: Assuming that we wish to ascertain the sweetening value of those solutions of saccharin which correspond, judging by their taste, to a 2 per cent solution of cane sugar. We first prepare two solutions of saccharin, one of which is decidedly sweeter while the other is decidedly less sweet than the standard 2 per cent sugar solution. We next prepare a series of saccharin in solution, whose concentrations vary between the above limits, and which vary in equal degrees from each other. The examination made of these consists in a precisely regulated comparison of the sugar solution with each of the saccharin solutions, of which there are nine in all. The examination thus made must carefully eliminate all errors due to chance or irregularities. Moreover, a constantly increasing number of observers must take part at the same time in the experiment; this is probably in order to obtain a great many individual judgments, so that by the averaging of these individual errors may be excluded so far as possible. The temperature of the room and of the solution, as well as the time of day and the immediate surroundings, must be the same for all persons making the experiment. Each pair of solutions, *i.e.*, the sugar solution and one of the series of saccharin solutions is tested twice, the order being reversed the second time, by which means the influence of the so-called "position in time" is eliminated. A judgment must be expressed after every testing of the two solutions compared; this condition is required by the regard to the position in time as well as the deadening of the sensation and the fatigue otherwise involved. For the same reasons the solutions must always be tasted at a given word of command, so that all the time conditions of the observation are the same for all the observers. This applies especially to the intervals between the tests, during which intervals water, white bread, and red wine are taken, this likewise being done at the word of command. The different pairs of solutions can be tasted in any order desired, provided the same order in the series is followed by all the observers; sometimes the sugar solution is tasted first and again that of the saccharin takes precedence. In order to avoid the power of suggestion the solutions are given arbitrary figures. The data included in the judgments expressed comprise a statement as to which solution tastes the sweeter, whether they show an equality of sweetening power, and, finally, whether the tester is unable to decide between the two.

In a test of this kind in which three to four hundred judgments were expressed, these were first represented graphically. A certain regularity in their distribution is evident which is to be explained by the principles of the laws of probability. The formula equation chosen makes it possible to ascertain a definite zone for the judgment of equality. From this there is to be obtained likewise a definite chief value with higher and lower deviations therefrom.*

In numerous experiments of this sort, this process has given excellent results, as shown particularly by the amazing similarity of the values found. It should be remarked that this method is applicable, not merely to this particular case, but can also be readily applied to all related questions and its successful application strikingly exhibits the growing importance of the new science of experimental psychology.—An address delivered by Dr. R. Pauli before the congress of German naturalists and physicians in Nauheim, September 20-25, 1920. Translated for the *Scientific American Monthly* from *Die Umsau* (Frankfurt) for October 9, 1920.

TEST OF LARGE GRAIN HOPPER SCALE

The importance of scales in every variety of business which is concerned with the buying and selling of commodities by weight is, of course, well recognized by everyone. In order to transact business on an honest basis, it is necessary that these scales be tested by someone in authority to determine whether they come within the required tolerances as to accuracy. Such work presents no particular difficulties when small capacity scales, such as are used in retail stores, are all that has to be considered. Many complications arise, however, in connection with the very large scales now used by the railroads and industrial concerns. The railroad track scale testing equipments maintained by the Bureau of Standards have been referred to in previous numbers of the Monthly.

Recently the Bureau conducted a test on a grain hopper scale of 120,000 lb. capacity located at Kansas City, Kansas. The work was done for the State of Kansas and other interested parties, including the Southwestern Milling Company, the Kansas City Chamber of Commerce, a number of railroads, the Western Weighing and Inspection Bureau, and the manufacturer of the scale. The test was one of the most thorough ever given to a scale of this kind. In addition to the ordinary testing, the dimensions of the scale parts were carefully measured and its capacity determined by means of computations based on these dimensions. Such work as this is of the greatest value to the public as it affects the buying and selling of very large quantities of grain and the wholesome influence of such a test, even when made upon only one of these large scales, is very important and nearly always results in the improvement of other scales in the vicinity.

As a part of the work in connection with the testing of a scale, the Bureau makes recommendations for the better maintenance of that particular installation and its recommendations have been followed to good advantage in nearly all cases.

*More precise details concerning this experiment, together with references to the sources of information, can be found in *Psychologisches Praktikum* (Jena), 1920, second edition.

Research Work of the United States Bureau of Standards

Notes Specially Prepared for the SCIENTIFIC AMERICAN MONTHLY

COOPERATIVE WORK IN CONNECTION WITH ELECTROPLATING

IT is to be regretted that many industries do not realize that a time of relative industrial depression is just the time to push investigational work. Ordinarily, when the demands for a product are very great, it is extremely difficult to carry out research work successfully, as all the energies of the manufacturer must be bent toward increased production. When business is dull, a comparatively small outlay may be wisely expended for industrial research, the fruits of which will be available when the demand for heavy production again occurs.

During the past month a member of the Bureau's staff has pointed out the importance of work of this kind in addresses delivered before three branches of the Electroplaters' Society. The importance of and possibilities for research in electroplating were pointed out and the desirability of conducting such work at this time, because of the reasons outlined above, was indicated. The close coöperation of the Bureau with the manufacturers and research men engaged in this industry should receive every encouragement as electroplating is an extremely important manufacturing process and has until lately received but little scientific attention. Through such meetings as the three just mentioned, the Bureau's staff is enabled to become better acquainted with those engaged in the industries and the problems which are in need of study. It is hoped that through such association it will be possible to make the work of the Bureau more immediately useful and also secure a more extended application of the results in everyday electroplating work.

THE CARBONIZATION OF LUBRICATING OILS USED IN INTERNAL COMBUSTION ENGINES

THE formation of the so-called "carbon" in automobile engines is one of the greatest sources of trouble for the average owner of a motor car. Much of this is attributed to the comparatively low grade of gasoline now available and some to the lubricating oil. A recent publication—Circular No. 99 of the Bureau of Standards—is devoted to this important subject. The nature and effects of the deposits formed in internal combustion engines are discussed and it is shown that the term "carbon" is a misnomer because the deposits consist largely of asphaltic matter. Brief accounts are given of the nature of petroleum oils and of the theories of formation of deposits. The oxidation and cracking of petroleum are discussed in detail. The next section of the circular takes up carbonization tests which depend upon oxidation and upon cracking, and full descriptions are given of the apparatus and procedures for the "Waters" and "Conradson residue" tests. Distillation methods are also touched upon and a general discussion gives brief summaries of certain controversial papers. and finally points out that there is yet much to be learned upon the subject of the lubrication of internal combustion engines.

TESTS OF LEATHER MADE FROM RABBIT SKINS

THERE has been received through the Bureau of Foreign and Domestic Commerce several samples of leather made from Australian rabbit skins. These samples were tested for tensile and tearing strength. The tensile strength was low, averaging from 800 to 1,200 lb. per sq. in. as compared with 4,000 lb. per sq. in. for calf skin leather. The leather also exhibited but little resistance to tearing. Some of the raw pelts were tanned in the laboratory by the one-bath chrome process, the resulting leather having about the same physical properties as the original samples. In general, the samples had many surface defects which would impair their cutting value and the small size of the skins would tend to cause considerable waste. However, it is thought that the leather could be employed for linings, novelties, and other similar work. A recent United States Consular report states that the leather has been used for shoe uppers.

HARDNESS OF STEELS PRODUCED BY ABRASION

THE relative hardness of various types of steels produced by subjecting all to the same abrading influences has been determined with the following results: In all cases except the high-carbon austenitic steel, no pronounced effect of the abrasion upon the steels used in these experiments was observed. In all cases the hardness of plain carbon steel is increased and among steels of this type the steel containing 0.85 per cent shows the greatest increase in hardness. The alloy steels generally show a smaller increase in hardness of abraded surface than plain carbon steels, and in some cases they show a decrease of surface hardness. High-carbon austenitic steel shows a marked decrease of Brinell and scleroscope hardness. The process of abrasion viewed in the light of Beilby's theory may be considered as resulting in the production of amorphous matter at the expense of crystalline matter which affects the hardness of the abraded surface of the metal but probably not the general character of its structure. As to the decrease of Brinell and scleroscope hardness of high-carbon austenitic steel, the following explanation may be suggested: According to Benedick's Pressure Theory, the martensite should be present in a greater amount on the lower layer of the examined specimen than in the inner portion and it seems possible that if the surface layer is ground away the next or more austenitic layer should be found to be somewhat softer.

TEMPER BRITTLENESS OF STEELS

AN extensive review of the literature on this subject has been made with the result that the nature and occurrence of temper brittleness may be summarized as follows: Certain steels which have been hardened by quenching from temperatures above the A_3 point and tempered at temperatures ranging from about 450 to 600° C. show low impact values if they are cooled slowly from tempering temperatures as compared with those cooled quickly. The cause of this phenomenon, which is also referred to as "Krupp Krankheit," has not yet been clearly established. The property of temper brittleness has been found present in carbon steels .25 to .4% C., nickel, chrome-nickel, chromium, and certain other alloy steels. Chromium-nickel steels of the same chemical composition and heat treatment have been found to vary widely in their susceptibility to temper brittleness and even in the opposite direction, *i.e.*, the slowly-cooled specimens were tougher than the quickly-cooled ones. The process of manufacture appears to have more of an influence than small changes in chemical composition, thus, steels made by the acid open-hearth process are more prone to temper brittleness than electric or crucible steels. The opinion has been advanced that the degree of work and the temperatures employed during the process of fabrication from the ingot bear some relation to the degree of susceptibility to temper brittleness. Other factors appearing to have an influence on the subject are the temperature of hardening preceding tempering treatment, degree of hardening, as cooling in water, oil, or air, the rate of cooling from tempering temperature, phosphorous content, and the furnace atmosphere

in which the material is treated. Other questions bearing upon the problem and upon some of which no general agreement has been reached and concerning which but little knowledge appears to be available are: relations between microstructure and susceptibility to temper brittleness, path of rupture, heating and cooling curves, relation between impact values and tensile test values as well as the Brinell hardness values, and the influence of the shape of the notched specimen upon impact test values.

CAUSES AND PREVENTION OF THE FORMATION OF NON-CONDENSIBLE GASES IN AMMONIA ABSORPTION REFRIGERATION MACHINES

TECHNOLOGIC PAPER No. 180 on this subject has recently been issued and may be secured in complete form from the Superintendent of Documents, Washington, D. C., at a cost of 5 cents per copy. The paper may be summarized as follows:

In the experiments conducted at this Bureau, the conditions existing during the operation of an ammonia absorption refrigeration machine were duplicated. It was found that the presence of the non-condensible gases that cause so much trouble in the operation of these plants is due to either of the following causes: (1) leaks of air into the system, and (2) the corrosive action of the aqua ammonia on the metal of the plant.

If the foul gas is mainly nitrogen, the gas is derived from the air that is leaking into the system. The oxygen originally present in the air is quickly used up when the plant is operated and so will be present in only a very small percentage of its original amount. On the other hand, if the foul gas is hydrogen, the cause is corrosion by the ammoniacal liquor. Pure aqua ammonia will not cause gas formation but if salts of such weak acids as acetic or carbonic acid are present in the aqua, the corrosive action will continue during the life of the charge. If the gas in the plant contains both nitrogen and hydrogen, both causes are present.

The corrosive action of impure aqua may be completely stopped by the addition of either sodium or potassium dichromate to the aqua in the plant. The dichromate is conveniently added in the form of a concentrated solution and gas formation will be stopped if the salt is added to the extent of .2 per cent of the weight of the aqua present. It is best to add the dichromate to the charge in all plants as its presence decreases the very small amount of gas caused by even the highest grade ammonias.

THE YEAR'S PROGRESS IN RADIO TELEPHONY

THE Radio Section of the Bureau has for some time devoted a great deal of attention to radio telephony and as the year closes it is of interest to note the progress which has been made in this art, both in the Bureau's laboratories and elsewhere. The past year has witnessed steady progress and increasing public interest in radio telephony, and voice transmission by radio waves has advanced from the experimental stage to established practice for distances of a few hundred miles. All inherent difficulties have been surmounted so that it is possible to carry on reliable radio telephony over as great a distance as ordinary wire telephony and it seems entirely probable that the transmission of speech commercially across the Atlantic will be an established fact in the not far distant future. The quality of transmitted speech or music by this means is as perfect as in ordinary wire telephony.

The essential characteristic of radio telephony is the use of high-frequency waves which act as carriers for the relatively low-frequency current which reproduces the sound alternations. The carrier-waves may be radiated into space in all directions or may be guided along conductors. Furthermore, radio ar carrier-wave telephony may be linked with or connected to ordinary wire telephony. These developments unquestionably point to the supplementing of the ordinary systems of telephony by radio methods.

DEFINITIONS AND SPECIFICATIONS OF LIME

A PREVIOUS publication on this subject has already been referred to in the MONTHLY. Circular 106 is now ready for distribution by the Superintendent of Documents, Washington, D. C., at 5 cents a copy. It contains briefly the following information:

Limestones are classed as high calcium or magnesiam according to the ratio of lime to magnesia which they contain. According to their physical structure, they vary from marble to chalk. Crushed stone of various sizes is used for blast furnace flux, aggregate for concrete and asphalt, ballast, road metal, sand, whiting, etc. It is also a basic raw material used in the manufacture of cement, glass, pottery, and many other things. Agricultural lime used as a fertilizer may be ground limestone, quick lime, or hydrated lime. Quick lime is made by burning limestone. It is used as a building material and as an ingredient of mortar and plaster. Slack lime is made by adding water to quick lime to form a body. Hydrated lime is made by adding just enough water to quick lime to form a dry powder. It is used as a building material instead of quick lime and also as an addition to cement, mortars and concretes. Both quick lime and hydrated lime are used as basic raw material in the manufacture of paper, sugar, bleaching powder, alkalis, etc. Air-slacked lime is worthless as a building material and is seldom an article of commerce. Quick lime is shipped in barrels holding 180 or 200 lb. and hydrated lime in paper bags holding 50 lb.

The circular describes the quantity of lime required for making plaster and mortar as well as the amount for use as fertilizer. A formula for making whitewash is likewise included. Hydrated lime should contain not more than 5 per cent impurities nor 3 per cent carbon dioxide. It should be of such fineness that not more than ½ per cent shall remain on a No. 30 sieve nor more than 15 per cent on a No. 200 sieve. It should pass the prescribed steaming test for soundness.

THE MAGNETIC TESTING OF TWIST DRILLS

THE determination by magnetic tests of inhomogeneities in steel is a new method which is now assuming considerable importance. During the war the Bureau developed an arrangement by which imperfections in rifle barrel steel could be easily detected, thus allowing the manufacturer to throw aside any imperfect material without having to wait until the same had been subjected to a finishing process to discover the flaws.

Within the past month the Bureau has commenced a cooperative investigation with one of the committees of the American Society for Testing Materials on the testing of twist drills by magnetic analysis. One of the members of the committee has prepared the steel by a special process and the test for homogeneity will be made by the magnetic method developed at the Bureau. The drills are to be manufactured by another member of the committee under carefully controlled conditions and will again be tested magnetically. After the drills have been finished, they will be returned to the manufacturer who is to subject them to a thorough mechanical test. After all these data have been secured, the committee will meet and attempt to find whatever correlation may exist between the mechanical performance of the drills and the results of the magnetic analyses. The ultimate object of this investigation is the development of apparatus which can be used in a commercial way for the non-destructive testing of twist drills.

RECENT PUBLICATIONS ON PAINT

THE following Bureau of Standards circulars are now ready for distribution and may be bought from the Superintendent of Documents, Washington, D. C., at 5 cents a copy:

Circular 102.—Recommended Specification for Composite Thinner for Thinning Semi-paste Paints When the Use of Straight Linseed Oil Is Not Justified. Circular 103.—Recommended Specification for Spar Varnish. Circular 104.—Recommended Specification for Asphalt Varnish. Circular 105.—Recommended Specification for Liquid Paint Drier.

Notes on Science in America

Abstracts of Current Literature

Prepared by Edward Gleason Spaulding, Professor of Philosophy, Princeton University

OPTIMUM NUTRIENT SOLUTIONS FOR PLANTS

During recent years numerous investigators have devoted considerable time and resources to the study of the salt requirements of various plants. Plans have been proposed for the extension of this work, with the hope that certain fundamental data may be obtained which shall indicate the composition and concentration of the solution or solutions best suited to the growth of the plant. It now seems to be an opportune time to raise the following questions: First, it is probable that the plant has any definite response within broad limits, to a particular ratio of salts or ions contained in the complete nutrient solution; and second, assuming the existence of such optimum solutions, are the methods generally employed adequate to determine their composition?

During the course of an investigation on certain phases of plant nutrition, an experiment has been carried out in connection with the first point. Three series of nutrient solutions were prepared containing different percentages of K, Ca, Mg, PO_4, NO_3, and SO_4, and measurements were made of total weights and average lengths of tops and roots.

The experiment showed that solutions of radically different concentrations and salt proportions do not affect the yield of the crop to any important extent. This does not mean, however, that certain solutions (possibly including those containing large proportions of magnesium salts) may not inhibit plant growth because of unfavorable physiological balance. The point which it is desired to make is that the range of equally favorable ratios between nutrient salts is probably a very broad one, no doubt including the solutions of most soils. This conclusion is not surprising in view of the observation that under proper climatic conditions many different types of plants can grow vigorously on any fertile soil, while a given type of plant may grow equally well on various soils, the extracts of which have entirely different proportions of nutrients. Again, plants of equal development may store nutrient elements in very different ratios, when grown in different soils or solutions.

It has sometimes been suggested that solution and sand culture experiments offer a fundamental means of determining fertilizer requirements of soils, in connection with a proper physiological balance for the plant. If one considers the dynamic nature of the soil system, with its constantly fluctuating soil solution and the reactive properties of the soil minerals, it seems scarcely within the limits of possibility to alter a soil solution to fit any particular ratio of nutrients. The addition of any one fertilizer salt may affect all the various components of the soil solution. Moreover, many elements are present in the soil solution besides those added to the artificial culture solutions and it may not be assumed that these are without effect on the physiological balance of the solution, if indeed such a balance is of importance ordinarily.—Abstract from an article by D. R. Hoagland of the Division of Agricultural Chemistry, University of California in *Science* for December 10, 1920.

THE ABSORPTION-TRANSPIRATION RATIO IN PLANTS

In *Science* for November 26, 1920, Mr. E. S. Johnston of the Maryland Agricultural Experiment Station directs attention to a method of studying the absorption-transpiration ratio in nutrient media.

Several writers have shown that the water content of plants varies with the hour of the day. This variation is of course due to differences in the rates of water entrance and exit. Wilting takes place when the ratio of the rate of entrance to the rate of exit is less than unity whether caused by excessive transpiration or by a decrease in root absorption. These two plant processes may easily be studied by using water culture plants exposed to different environmental conditions or placed in solutions of different osmotic pressures. The following experiment was made by Mr. Johnston to illustrate the manner in which changes in the strength of solutions affect the ratio of absorption to transpiration:

The roots of a tomato plant were passed through a hole in the rubber stopper of a large mouth bottle of about 600 cc. capacity. A watertight seal was made around the stem of the plant; a 2 cc. pipette, graduated to 1/20 cc. and a thermometer were inserted into the bottle through the stopper. The bottle and pipette were then filled with the nutrient solution, care being taken that no bubbles were inclosed beneath the stopper. Loss in weight of the plant and container gave the amount of transpiration, while the loss of solution from the pipette gave the amount of root absorption after temperature corrections were made. These corrections were made by comparing the pipette readings with those of a pipette in a similar bottle containing no plant, but exposed to the same set of conditions. Transpiration was measured in grams while absorption was measured in cubic centimeters, but as the variations in density of the solutions for these temperature ranges were small in comparison to the actual values dealt with this correction was not made.

The following table gives the data showing rates of transpiration and absorption of a tomato plant with roots immersed successively in a three-salt nutrient solution of 1.75 atmospheres osmotic pressure, cane sugar solution of 5.06 atmospheres osmotic pressure, and distilled water:

Period	Hourly Rate of Transpiration gram	Hourly Rate of Absorption cc.	Ratio A/T	Solution and Osmotic Pressure
1	.41	.44	1.07	3-salt, 1.75 atm.
2	.31	.37	1.19	3-salt, 1.75 atm.
3	.42	.28	.67	Sugar, 5.06 atm.
4	.29	.18	.62	Sugar, 5.06 atm.
5	.41	.46	1.12	Distilled water
6	.32	.39	1.22	Distilled water

When the hourly rate of absorption is in excess of transpiration the ratio, A/T, is greater than unity and the plant cells increase in turgor. When this rate is less than unity turgor is decreased and if the process is continued long enough the cells become flaccid and the plant is seen to wilt. The plant gained in turgor during the first two periods given in the table, but during the third and fourth periods the ratio values decreased very much. This decrease was mainly due to lower absorption rates since the roots were surrounded by a solution much stronger osmotically during these two periods than during the first two. The rates of absorption for the last two periods were greatly increased by placing the roots in distilled water.

THE COMPOSITION OF GASES IN RIPENING FRUITS

A study of the ripening processes in fruits and of the chemical and physiological changes associated with them, raises the question as to what may be the composition of the gas in the intercellular spaces. The gas within the tissues constitutes in part the medium in which the processes associated with the life of an organism take place. It is only reasonable to suppose that the composition of this medium may exert some influence upon the rate or nature of the changes taking

place. However, owing to the difficulty of extracting the gases from the interior of the tissues plant physiologists have almost entirely neglected studies along this line.

An apparatus has been devised for obtaining a sample of the gas from within the tissues without contamination with air. The use of this apparatus showed in the case of Yellow Newton apples, that the percentage of CO_2 in the gas within the tissues increases markedly at higher temperatures, at the same time that there is a corresponding decrease in the percentage of oxygen present, the average ranging from 142 per cent at 2 degrees C. to only 3.2 per cent at 30 degrees C. The data collected, representing averages of a number of determinations, clearly indicate that a marked variation may occur in the composition of gas in the tissues under varying conditions of temperature.

Three main factors are found to operate to determine the amounts of CO_2 and oxygen in the intercellular spaces at any given temperature. These are (1) the rate of oxidation, or the rate at which oxygen is taken up from, and CO_2 given off into, the intercellular spaces; (2) the permeability of the skin or epidermal covering to CO_2 and oxygen; and (3) the difference in pressure of CO_2 and oxygen within and without the fruit, which determines the rate of gaseous exchange when the permeability factor is constant. The effect on each of these factors of varying the temperature will explain the variation occurring in the internal atmosphere of the tissues studied at the different temperatures.

From a consideration of these relative effects of temperature on oxidation and on permeability, it is apparent that the absorption of oxygen and release of CO_2 are increased much more by a given rise in temperature than in the tendency for oxygen to be supplied to the tissues, and CO_2 to be given off from them. Consequently, as the temperature is raised, the amount of oxygen in the tissues becomes less and less, while the CO_2 accumulates correspondingly. This continues until the third factor becomes effective, that is, the difference of CO_2 and oxygen pressures within and without the fruit becomes so great that equilibrium is again established.

No attempt has been made in this preliminary work to associate the percentage of CO_2 and oxygen found with the processes taking place in the fruit. The data presented, however, clearly indicate the necessity of taking this factor into consideration in many types of horticultural and physiological investigations. It should be given attention in studies of the effect of temperature upon the processes in plant tissues, for it is readily apparent that much variation may be caused by the composition of the medium in which these processes are carried on. Of special importance is the application of studies of this type to the questions as to the effect of wounding and various other treatments on the respiratory processes in tissues. Finally, it is of prime importance to know the composition of the internal atmosphere in studying the effects of various gases, etc., on plant organs. Some work has been done on the effect of various gases on fruits and vegetables in storage. Obviously, it is essential in such work that the composition of the internal atmosphere be known.—Abstract from article by J. R. Magness in *The Botanical Gazette* for Oct., 1920.

MENTAL TESTING AND THE EDUCATION OF HANDICAPPED CHILDREN

In a long article published in a recent number of the *American Journal of School Hygiene*, Dr. J. E. Wallace Wallin, director of the Psycho-Educational Clinic of the St. Louis Public Schools, discusses the general problem of Handicapped Children.

As showing the seriousness of this problem, Dr. Wallin says that many years of experience in examining children in the St. Louis public schools has led him to believe that the percentage of feeble-minded children in the elementary schools of this system is about one-half of one per cent. An estimate which agrees with Dr. Walter Cornell's estimate for the Philadelphia schools and Dr. Clara Schmitt's estimate for the Chicago schools. If this ratio held throughout the country there would be over 102,000 feeble-minded children in the public and private elementary schools of the United States.

Dr. Wallin's experience in the St. Louis public schools further indicates that for every feeble-minded child there are from five to ten children on the borderline of mental deficiency who require individual and differentiated instruction in ungraded classes and elementary industrial schools. The assumption is probably conservative that at least 3 per cent of elementary pupils throughout the country classify in this group, giving an estimate of over 615,000 pupils (aside from the feeble-minded mentioned above) who are too backward to do successful work in the regular grades.

Concerning the educational methods to be used in meeting the problem of these subnormals Dr. Wallin finds that they are most successfully trained in centers apart from the elementary schools and apart from other types of special classes, such as the classes for incorrigible, truant or backward pupils. No child should be assigned to a class for the feeble-minded unless he has been properly certified as a result of a careful investigation of his history and present mental and physical condition. It is most important that the child be given a careful psychological examination. The majority of candidates should be tried out in the kindergarten and first grade before they are reported, while children who cannot be definitely certified as a result of the examination to be mentally defective, should be given the benefit of the doubt and be assigned to ungraded classes for further trial under most favorable conditions.

The curriculum for mental defectives should include the rudiments of the literary branches, which should be presented concretely and in correlation with practical industrial problems; sensorimotor exercises; industrial training; physical training; moral training, mostly habituation in correct modes of response; speech improvement and correction; and musical training. The guiding aim of the program of studies in the special school for mental defectives should be distinctly practical rather than cultural.

NEW FIELDS OF PHYTO-CHEMICAL RESEARCH

Dr. Edward Kramers in the October number of the *Journal of Industrial and Engineering Chemistry* points out how the cultivation of medicinal plants on an economical scale as has been done at the Wisconsin Pharmaceutical Experiment Station presents new opportunities for research, particularly regarding milling and distillation problems. As Dr. Kramers points out a scientist who has conducted experiments on a laboratory scale finds a new set of problems confronting him when he undertakes to distil the plants from an acre of peppermint or to mill half an acre of belladonna plants. The author records the observations of a scientist pointing out that while some of the problems overcome may be old to the technologist, the technologist does not frequently record his experiments for the benefit of the scientist, so that any record of scientific observation is of value. He says: "If it required years of study to isolate and identify the oily constituency of plants it will no doubt require years and years to study their water soluble voluble constituents. If for years the writer has desired to devote to these latter constituents such attention as they seem to merit he has also wanted for the same length of time to study those products which escape from the condenser and are not collected either in the separated oil or the aqueous cohobates. The study of these escaping vapors will require, as experience has already shown, especially constructed condensers and absorbers. Thus will be trebled in size as it were this one field of phyto-chemistry." It is evident that if plant chemistry is to advance in this country the biochemical study of the plants and the study of the problems involved in large technological operations must go hand in hand.

Progress in the Field of Applied Chemistry

Notes Culled from Current Technical Literature

By H. E. Howe, Member of American Chemical Society

RUBBER ANALYSIS

THE *Chemical Bulletin* for December printed an article by John B. Tuttle on "The Interpretation of Rubber Analysis." The constituents of rubber compounds can be classified as rubber, sulphur, accelerators, and fillers, and an analysis of rubber compounds should be designed to develop the facts regarding these groups and the significance of these facts should be determined by experienced chemists. At present the principal tests are acetone extract, chloroform extract, alcoholic potash extract, ash, total sulphur, free sulphur, mineral and organic fillers, with special methods for the detection and determination of oils, glue, paraffin and the like. Fatty oils such as palm oil and cotton seed are probably added for their softening effect, but mineral oils usually denote reclaimed rubber. Paraffin wax is used to close up minute pores in the rubber for insulated wire. The various extracts named are for the purpose of separating the constituents soluble in the reagent used. Thus the acetone extract may contain resinous matter from the crude rubber, the free sulphur oils and waxes. The rubber resins run about 2 to 4 per cent in high grade material and a higher percentage indicates low grade or reclaimed rubber. The expert is guided in judging the grade of rubber used by the properties of these rubber resins. The chloroform extract brings out the bituminous substances. It is only qualitative, but the results it yields are important. The alcoholic potash dissolves the oil substitutes and if an amount greater than one per cent of the rubber present is found the use of oil substitutes is indicated. The interpretation of ash is difficult for some fillers enter into new compositions on heating and others are more or less volatile.

The usual practice is to obtain the percentage of rubber by difference and while its actual determination is important it is seldom made. This is largely due to the difficulty of making an accurate determination and a great deal of time has been spent in an effort to develop a satisfactory method.

The various methods are not as accurate as might be wished and the results of any analysis should be accompanied by reference to the methods by which they were obtained. The interpretation of the analysis cannot be made without careful consideration of the methods, the probable error which they involved, the purpose for which the article is to be used and some knowledge of the effect of the various constituents upon the service which is expected.

A NEW MOTOR SPIRIT

MUCH has been written on this subject and Dr. Juritz in *Journal of Industries* (South Africa) briefly reports the result of researches by S. W. Blake, which has led to a patentable process yielding fuel known as acetol although that word already has a specific meaning in chemistry, being applied to an organic substance. While full details are not yet available it is reported that the object of Mr. Blake's invention is to make possible the blending of acetylene gas with alcohol through the use of a second solvent. In discussing the use of alcohol, which is more satisfactory when mixed with other fuels, it is pointed out that more recent efforts have been directed toward finding a substance which would be more effective and less expensive than ether, and since a liquid like ether forms an efficient mixture with alcohol because it is so easily converted into a volatile highly combustible vapor it seemed rational to introduce a ready formed inflammable gas in large proportions into the alcohol. Acetylene suggested itself because it is highly explosive when mixed with air and apparently does not injure the metals and oils of the engine. Now alcohol and ether can be mixed with each other in any proportion, giving a gradation to meet the variety of requirements, but if acetylene is substituted for the ether this latitude of grading becomes impossible since a point is reached beyond which the introduction of acetylene gas into alcohol gives proportions which refuse to mix, six parts by volume of acetylene to one part of alcohol being the limit.

At this point Mr. Blake conceived the idea of using with the alcohol a second solvent in which liquid acetylene might dissolve more readily than in alcohol, and ultimately he found a liquid which can be added to alcohol in any proportion and a certain mixture has the ability of absorbing from three to four times the quantity of acetylene that alcohol can absorb alone.

As to the economic success of this method one must await the disclosure of further details, particularly those concerning the possible supply of the second solvent mentioned and the price which consumers can afford to pay for such a new fuel based upon the service which it is capable of rendering.

WHITE SUGAR IN NATAL

AT least one mill in Natal is operating the combined beet and cane sugar process which produces a sugar nearly equal to white refinery sugar direct from cane juice and with a greater recovery than has been experienced heretofore. Carbonization, which has always been a feature in the production of sugar from beets, is introduced in the treatment of raw cane juice and both a first and second carbonization are employed. A light colored syrup is obtained free from suspended and viscous matter; the time of boiling to grain is shortened by 20 per cent; a better separation of crystals from the molasses is secured; and there is an increase in the recovery of brilliant white sugar. The process enables the mills to use a greater amount of South African material, thereby reducing the imports of foreign chemicals tends to somewhat increase the food supply and is a further step toward self-dependency.

FORMALDEHYDE AND METAL CORROSION

IN the December *Journal of Industrial Engineering and Chemistry* there is reported a series of results undertaken to determine to what extent a small amount of formaldehyde in acids might inhibit the solution of the metal in the acid. Several grades of steel as well as wrought and cast iron were employed in the tests and it was found that the presence of one per cent of formaldehyde in a ten-degree B. sulphuric acid and also in a 1:1 hydrochloric acid solution decreases the solvent action of these acids to a marked degree especially in the case of wrought and cast iron and steel. The effect is less marked with 10 per cent nitric acid. The use of muriatic acid containing about one per cent of formaldehyde affords a convenient means of pickling rusty steel without appreciably affecting the surface of the steel.

STEEL WIZARDS, PAST AND PRESENT

THIS was the subject of Dr. Saveur's address before the American Society for Steel Treating at its last annual meeting. In his address Dr. Saveur brings together in a useful way many facts concerning the contributions of pioneers in steel making in the past and includes in his review reference to appliances which have played such an important part along with chemistry.

Among the Americans who are entitled to a place because of their notable inventions, discoveries or improvements in the

art of making wire or heating iron and steel or for scientific contributions to that art, the following are named: Campbell, who designed the first tilting open hearth furnace; John Fritz, the inventor of the three-high rolling mill; James Gayley, for conceiving and executing the dry air blast, which has been such an economic factor in steel making through the conservation of fuel; A. L. Holley, whose improvements in the construction of Bessemer Mills were notable; Henry M. Howe, whose contributions to our knowledge of steel have been invaluable. The use of mixers in steel making was introduced by W. R. Jones. High speed tool steel was discovered by F. W. Taylor and Maunsel White. Many useful appliances including charging machines and the improvements in the construction of open hearth furnaces are attributable to S. T. Wallman; and Frederick W. Wood introduced the car casting method for making steel ingots.

The address in full will be found in the November issue of the transactions of the American Society for Steel Treating.

NAVAL STORES

IN the November number of *Chemical Age* (New York) Mr. J. F. Carter, Jr., contributes an article under the title. "Plain Talk on Pine Stump Naval Stores Recovery." "At no time has there been so great a need as there is today for active military development of the processes for extracting the naval stores, turpentine and resin, from the stumps on the cutover lands of the long leaf yellow pine section of the South." Mr. Carter discusses the process by which such great quantities of cutover lands have come to lay idle and points out that much money has been lost in an effort to extract the turpentine and the resin from the stumps. There have been many failures most of which appear to have been due to a lack of adequate chemical knowledge. The extraction of naval stores from yellow pine stumps is strictly a chemical problem. Without good chemical advice the products obtained by most of the processes are so impure as to render them of low value, if indeed not valueless.

Destructive distillation is very sure to yield impure products at every step, due to the impossibility of control and the mixture of resins and ligneous products which come over. Steam distillation comes next in the scale. It takes out a large part of the turpentine, but not all, and leaves all else behind. Mr. Carter believes that steam distillation could only succeed in days of high priced turpentine. In the use of the less volatile solvents such as gasoline, benzine, naphtha, and carbon bisulphide, with the expense of the equipment and the recovery of the solvent as a drawback, there is necessarily a certain percentage of the solvent lost and the slowness with which the process can be carried out introduces an inconvenient time factor.

Mr. Carter then describes a process which he has worked out after some 17 years and he has given the name Triple Alkaline System to his method. Turpentine is recovered as pure turpentine, resin in the form of resins which can be distilled to get the various grades which the market demands, and chemicals employed recoverable with small loss.

DETECTION OF OILS OTHER THAN LINSEED IN PAINTS

BEGINNING on page 1189 of the December issue of the *Journal of Industrial Engineering and Chemistry* there is a discussion of the possibility of detecting oils other than linseed in paints by means of the hexabromide number of the fatty acids. The work is based on that reported by Steele & Washburn some time ago and is aimed at the simplification of the process reported. The article to which reference is made gives detailed description of the method and details of results obtained on pure linseed and other oils; such as soybean, tung, menhaden and mixtures of linseed with soybean oils. The authors give the following summary:

"A method has been developed for the detection of substitutes in linseed oil and paints based upon the determination of the amount of ether insoluble hexabromides by brominating the fatty acids under fixed conditions. The method is less complicated than some of those previously proposed and gives more concordant results. The hexabromide value of pure extracted or expressed linseed oils varies between comparatively narrow limits and is on the average about 42. The average hexabromide value of pure soybean oil is 6, and of tung and fish oils, zero. The latter, however, gives ether insoluble octobromides which can be readily separated from the hexabromides of the vegetable oils because of their insolubility in warm chloroform.

"The proportion of linseed oil in a mixture of soybean, tung, or fish oils can be determined much more closely by means of the hexabromide than by the iodine value of that mixture. It appears probable that by the method developed a close approximation of the composition of the unknown volatile vehicle of a paint may be obtained, but further study of the applicability of the method to paint analysis is desirable."

CEMENT FOR PORCELAIN

THE November *Journal of the American Ceramics Society* contains among its abstracts the following suggestion as to cement for porcelain. These cements are used in cementing porcelains and metal. The first is composed of ground flour spar, finely powdered glass and sodium silicate, commonly called water glass. The old standby, litharge, made into a paste with glycerine, is the second on the list. Another suggestion is a thick glue mixed with one-half part of boiled linseed oil. Another is zinc oxide, calcined magnesia, and sodium silicate in equal parts. This mixture should be dried slowly. Chalk or precipitated calcium carbonate and powdered zinc mixed in equal parts with sodium silicate is another formula. The final is 20 parts plaster of paris, 50 parts of fine ground flint and 30 of zinc oxide. This mixture is made into a thick paste with sodium silicate.

RESEARCH IN SOUTH AFRICA

IN the *Journal of Industries*, which is published by the Union of South Africa, a recent number reports industrial research in the Union which was being carried out by the Advisory Board of Industry and Science. The accomplishments include the commencement of the following special surveys: mineral, botanical, fisheries, waterpower, soil and zoölogical. Scholarships have been established for the encouragement of the study overseas by young South Africans especially in the subjects of commerce and industry. A technical officer has been appointed to the Department of Industries and the scientists have had a part in developing a scheme for the establishment of a permanent tariff board with the object of creating an elastic and scientific system of tariff to insure suitable conditions for the extension of the industries of the Union.

The Advisory Board is to be succeeded by the Department of Industries.

PETROLEUM REFINING PROBLEMS

H. M. HILL, Chemical Engineer of the Bureau of Mines, under the title, "Refining Problems of the Petroleum Industry" in *Chemical Age* (New York) for November, emphasizes the fact that most of the problems in the industry are of minor importance when compared with the serious problem, that of obtaining adequate quantities of crude petroleum, and points out that the skimming plants that now surround the older producing fields have a difficult problem to face. The larger refineries at the terminals of trunk lines or those that have their own production are not likely to be so greatly affected by conditions which made the refineries in operation in 1918 and 1919 capable of refining more crude oil than is produced in our country.

Mr. Hill discusses the types of refineries, the topping plants where the lighter fraction is removed from the crudes and the skimming plants which remove only the lighter fractions from crude petroleum. Complete refineries are those that

manufacture lubricating oils in addition to the products produced by the skimming plants. Some refineries are equipped with cracking plants.

The five major products derived from petroleum are discussed at some length, these being gasoline, kerosene, lubricating oils, gas oil and fuel oil.

A great deal of constructive work will be expected of the American Petroleum Institute recently established to promote research and other constructive work in the petroleum industry for the solution of some of these pressing problems.

NEW FIBERS

In the December 22nd issue of *Chemical and Metallurgical Engineering* appears an account of a new German vegetable fiber industry which is centered in the plant of the German Fiber Material Company established in 1912. China grass, Australian seaweed, and jute have received the most attention. The vegetable fiber derived from the China grass is known as solidonia and is similar to ramie. By a secret process a long, stout, fine fiber is made from this grass, the curliness being a special feature. This makes it possible to mix quantities of the fiber with wool and it has been used extensively in underwear and woolen goods. Since it does not shrink as does wool it has a certain value in the manufacture of underwear.

Solidonia has been used in Germany for the manufacture of table linen, hosiery, which are difficult to tear, machine belting and sporting jackets. The army cloth, composed of 75 per cent wool and 25 per cent solidonia, is said to surpass in tensile strength any pure wool cloth. Much of the material has been used in the United States.

Another fiber called posidonia is derived from Australian seaweed. This is said to be equal to medium staple wool and it is spun on the worsted and the woolen system. The fiber is elastic and springy and the cloth made from it without the mixture of other fibers shows little if any creasing. It is said to be well suited to carpet manufacture and before the war sold at half the price of shoddy.

It is claimed that a special chemical process produces a long, fine, beautiful fiber from jute having characteristics enabling it to be spun on the worsted system pure or mixed with wool. Beginning with the manufacture and sale of fibers, the company in question has now extended its activities to spinning and may presently engage in weaving.

FORMALDEHYDE IN LEATHER MANUFACTURE

As long as 20 years ago formaldehyde solutions of about .3 per cent were used for preserving hides but such hides then required the use of sulphurus, formic or other weak acids to the soaks and of sulphide to the limes. A plumper leather is obtained by swelling the hides with acid after they have come from the stick vats and then fixing this swelling by treatment with formaldehyde. After this treatment, the tanning may be completed in strong rocker liquors followed by drumming but without the usual disadvantages. Formaldehyde is also used in fixing the hair of fur skins and is sometimes employed for stiffening the grain of loose hides. If tawed skins are treated with formaldehyde, then neutralized, washed, fat-liquored and bleached they are made resistant even to hot water. A complete article on this subject is to be found in *Le Cuir*, IX, 229-32 and 242-46 (1920).

THE HIGHER ALCOHOLS

A note has been made elsewhere concerning the importance of the organic chemical industry, and in nearly all work in that field the various alcohols of high purity are of greatest importance. The manufacture of such refined reagents and related substances is therefore of interest. One of the largest companies interested in the production of alcohol has begun the preparation on a commercial scale of refined alcohols, acetates, and ethers.

There is a considerable series of alcohols, the first two of which are the ones with which most people are best acquainted. Methyl, or wood, alcohol is the first of the series followed by ethyl, or grain, alcohol. If we write the arrangement of the atoms for the first we find it to be a carbon atom with which three hydrogen atoms and one hydroxyl (OH) group are connected, while the second consists of carbon with the three hydrogen atoms linked with a second carbon, holding two hydrogen atoms and the hydroxyl group. This gives us the beginning of a chain which may be extended until there are many carbon atoms, the first holding three hydrogens, the last, two hydrogens and a hydroxyl group, and the ones between connected with a carbon atom on each side and a hydrogen atom both above and below the line. Thus we have the so-called higher alcohols such as amyl, butyl, propyl, etc. The acetates and the ethers have their starting point in these various alcohols.

The alcohols are commercially important; thus isobutyl alcohol is a starting point in the manufacture of artificial musk. Ethyl aceto-acetate is important in the manufacture of tartrazine, an important dye material. Heretofore, the difficulty of obtaining some of these compounds has retarded certain important research activities, so that chemists are glad to know that amyl alcohol, isobutyl alcohol, normal propyl, and the like are now available in addition to anhydrous methyl alcohol, analyzing from 99.7 to 100 per cent CH_3OH. Besides these, anhydrous ethyl acetate, ethyl aceto-acetate, and anhydrous methyl acetate are to be had. This list will doubtless be considerably extended and amplified in the near future.

BLAST FURNACE SLAG

A certain amount of blast furnace slag is utilized in the preparation of cement; but the possibility of molding this material into a variety of forms has always been attractive, and a British patent has now been granted T. F. Hoere which relates to the utilization of blast furnace slag in the production of bricks, blocks, tiles, and various other parts of buildings. The patent is abstracted in the August 25th number of *Chemical and Metallurgical Engineering* which states that, in addition to various uses in dwellings, the patent covers electric insulators, electric main conduits, the bed plates of electric generators, curbing, tanks, etc. Some inventors have had the idea that the molten slag might be immediately conveyed to an adjacent plant and molded without reheating, thus saving fuel costs; but the patent in question calls for breaking up the cold slag after which the particles are packed in the molds and the molds are then filled with a molten slag so as to bind the particles of graded slag together. The graded slag may be heated and the molten slag mixed with 10 to 15 per cent of silica, lime or other binding agents. Various oxides are used for coloring purposes. While in the molds the product may be heated and cooled to anneal it, and if for any reason molten slag direct from the blast furnace cannot be used the molds may be filled with the graded slag, mixed or not with such materials as soda, ash, cryolite, broken glass waste, etc., having a lower melting point than the slag and afterward heated to a temperature above the melting point of the slag. Various other ways of using the graded broken slag and the molten slag are covered in the patent.

FORMATION OF FERROUS SULPHIDE IN EGGS DURING COOKING

In the *Biochemical Journal*, Vol. 14, 1920, Tinkler and Soar report their finding that the greenish black coloration on the surface of the yolk of a hard boiled egg is due to the formation of ferrous sulphide. The sulphur compound in the egg white is probably decomposed, giving rise to hydrogen sulphide, which forms the ferrous sulphide. The decomposition of this sulphur compound may be checked by simply cooling the egg immediately after boiling, in which case the objectionable coloration does not occur.

Progress in the Field of Electricity

Summaries and Excerpts from Current Periodicals

By A. Slobod

RECENT PROGRESS IN METAL SPRAYING

Previous to the war the Schoop process of metal spraying was applied in this country primarily for obtaining protective coatings. References to the early literature on this subject will be found in the bibliography published by the Carnegie Library of Pittsburgh, entitled "Metal Corrosion and Protection" and in its supplement published in 1915 in Proceedings of the Engineers Society of Western Pennsylvania. A chapter on this subject will also be found in the book by Flanders—"Galvanizing and Tinning."

During the war and after the Schoop process has made great strides in Germany. An electric pistol has been developed. The metal to be squirted is heated by means of an electric arc. Details are given in *Elektrotechnische Zeitschrift* for January 16, 1919, *Elektrotechnik und Maschinenbau* for January 5, 1919, as well as in the book by W. Kasperowitz and M. V. Schoop, entitled "Das Elektro-Metallspritzverfahren" (Carl Marthold, Halle a. S., 1920.) Its sphere of usefulness has been extended to include not only metal protection but also many operations formerly performed by soldering or brazing as well as all those cases where a metallic layer of one kind or another is desired. In the electrical industry, for instance, condenser plates could be prepared by depositing metal on glass; imperfect electrical contacts are eliminated; in the armature construction it could be used as a substitute for soldering and brazing; carbon electrodes or brushes could be firmly attached to the metal terminals; insulators may be coated with metal so as to improve in certain places the distribution of the electric field; light accumulator plates may be constructed by deposition; electric heating units can be manufactured by spraying the metal into proper forms; gloves, masks and wearing apparel in general can be covered with a layer of lead as a protection against the action of Röntgen rays or radium rays. These and many other possible uses are described in the book by Schoop which appeared last year and which is entitled "Das Schoopsche Metallspritzverfahren."

It is also interesting to note a paper by Robert Hopfelt in *Zeitschrift des Vereines Deutscher Ingenieure* for July 24, 1920, in which he gives a critical review of some of the recent applications of the Schoop process. He finds that the main drawback in many cases has been the porosity of the metal layers. Best results are obtained with zinc, lead and aluminum as coatings, while metal spraying upon wood, paper and textiles has not proven to be satisfactory.

The Schoop apparatus were handled in this country by the Metals Coating Company of America, formerly of Chicago, but now of Boston. Since the war their laboratories have been closed, but it is possible that these will be reopened when we finally make peace with Germany.

THERMOELECTRICITY AND THE CONDUCTIVITY OF METALS

The study of thermoelectricity seems preëminently to be fitted to reveal to us the real nature of the phenomena of heat and electricity. Of special interest is, therefore, the lecture recently delivered by Prof. Carl Benedicks, of the University of Stockholm, before the British Institute of Metals on the "Recent Progress in Thermoelectricity." His essential point was this: Metallic conduction is not to be ascribed to an "electron gas" filling up the space between the atoms, the metal acting as a cage for the electrons, but is due to the passing of electrons from atom to atom at the moments of the incessant collisions of the atoms which we assume, for other reasons, to occur even in solids. Without entering into much theoretical detail, Dr. Benedicks outlined his considerations and demonstrated the experiments which have led him to his "phoretic electron theory of metallic conductivity," which was stated as follows: If the electric charges be carried by the atoms and be not free, the increase in the kinetic energy of the atoms, and hence the heat generated must be equal to the work done and must be proportional to i^2, whether the atom in question preferentially assume a positive charge or a negative charge. That preference is not unimportant in other respects, however. Supposing an atom inclines to assume a positive charge e. Let it rebound between two atoms I and II, and let a potential difference V be established such that the positive current is from I to II. In position I the atom will assume a positive charge; owing to that charge it will be accelerated on rebounding until it reaches II and gives up its charge, to be reflected at now constant velocity. On colliding with I again, it is again accelerated, and so on. In this mechanism of conduction the average kinetic energy of the atom in position II must be greater than the average energy at I by a constant amount $eV/2$, and that signifies that the temperature in II must be higher than in I. Similarly it may be shown that for atoms inclining to assume a negative charge, the temperature would increase in the direction of the negative current. The former case would be that of platinum and of constantan, the latter—that of copper. Copper would be inclined to take up electrons, to associate them; platinum would be inclined to discard electrons—to dissociate them; lead, in which there seems practically to be no thermoelectric effect, would as readily associate as dissociate electrons.

It is evident that this theory is in contradiction to the law of Magnus, that in a homogeneous metal, whatever the temperature distribution, thermo-currents do not exist. To put the problem plainly, the question is broadly whether temperature difference and heat flow always go together with potential difference and electricity flow. In briefly reviewing the earlier investigations, Dr. Benedicks distinguished three periods: a first period, 1821 to 1838, of active somewhat uncritical experimenting; a second more critical period up to 1885 which finally accepted the law of Magnus, that no thermal current would occur in a really homogeneous metal, all apparent deviations being ascribed to impurities and to physical or chemical heterogeneity; and a third period, since 1898, which questions the law of Magnus. After five years of research Dr. Benedicks has arrived at the conclusion that this law cannot be maintained; he is its most eminent opponent and he demonstrated the reasons for his dissent. He performed many experiments, but he relies chiefly on the thermoelectric effect observed in mercury. Mercury is a liquid, as such free from internal stress, and obtainable in high purity; there it should be possible to decide whether the assumed Thomson effect is not after all merely a Peltier effect. Many experimenters have taken this latter view; but very careful experiments made with mercury in vessels of glass, or other materials, so constructed that hydrostatic-pressure stress could not arise, have convinced Dr. Benedicks that there is a thermoelectric effect in pure homogeneous mercury, and that it is of negative sign, as it should be. The effect is moreover proportional to the third power of the temperature, which is theoretically important, while it should be proportional to the first power in a heterogeneous circuit.

Having established that there is a homogeneous thermoelectric effect, Dr. Benedicks sought to determine whether there was inversely also a homogeneous electrothermic effect more

general than the Thomson effect, as one should expect if the analogy of the phenomena were complete. In the Peltier effect an electric current gives rise to a temperature difference and a heat transfer, even if the temperature be originally uniform throughout the circuit; in the Thomson effect, on the other hand, the electric current seemed to produce a temperature difference only when there was a temperature gradient from the beginning. By a long series of experiments on various metals and alloys, mercury, graphite, etc., Dr. Benedicks convinced himself that the analogy was complete. Thus two new (or formerly doubtful) Benedicks effects have been demonstrated; a thermoelectric and an electrothermic effect in a homogeneous circuit of one substance originally at uniform temperature throughout.—*Engineering*, Vol. 109, 1920.

PROF. W. H. ECCLES ON WIRELESS PROGRESS

Professor Eccles recently delivered an address before the Wireless Section of the Institution of Electrical Engineers in which he reviewed some outstanding features of the wireless development.

In 1913 musical spark method of transmission was still in use at some of the largest stations of the world, with the arc, the timed spark and the various forms of alternator as formidable rivals. Signals from spark stations were received by crystal detectors, by Fleming valves or by audions with two electrodes and continuous wave signals by the ticker and the tone wheel. Continuous wave circuits did not show outstanding advantages over spark circuits, for the heterodyne method of reception was cumbersome in practice and lacked many of the features which have made modern methods so successful. During 1913, however, the possibility of generating oscillations of very high frequency was realized and the heterodyne method of reception then sprang on to a different plane. For the three-electrode vacuum-tube aerial not only magnifies the signals at the same time as it generates the oscillations, but is so simple, perfect and manageable that it realizes the highest ideals of the wireless engineer. Combined with its positive retroaction between the anode and grid circuit it still possesses the rectifying property of the Fleming valve. It was thus found possible to generate local oscillations, to magnify the received signals and to rectify the combined result all with one tube. This gave to continuous wave wireless telegraphy an immense impetus over the spark method for long-distance work.

Such was the situation in England at the beginning of the war. Of the progress made since the most important feature has been the development of the triode, which instrument is now in the same stage of development as the dynamo machine was 40 or 50 years ago. To develop it it must be studied to the limits of its possibilities, endless measurements must be taken, and its theory must be built up.

After discussing briefly the voltage factor and giving a curve with the values of the voltage factor as the ordinates and the voltages of the battery permanently connected in the grid circuit as abscissae (the filament current being constant), the author mentions some anomalies of the triode working. It is found that the voltage factor undergoes great variation when tubes are used for magnifying rather larger changes of voltages than are applied to them in the bulk of wireless telegraph experiments. This leads to apparent anomalies when triodes are used for other purposes than the reception of faint wireless signals. It is possible that the changes usually occurring in the wave-lengths generated as the filament battery runs down owe their origin to the variations in the average value of the voltage factor, but by using the flat part of the curve the filament currents may be set so that this alteration will for a long time produce no change in the wave-length. The constancy of wave-length will become of growing importance as the world becomes crowded with wireless stations, and methods of transmitting within very narrow ranges of wave-length may have to be devised in combination with receiving antenna and apparatus with sharp tuning. The increased cost of low resistance antenna and apparatus will have to be compared with a possible saving of energy and other advantages of precise tuning.

The author then gives a relation for the remaining four principal variables of the triode: the anode current, the grid current, the anode voltage and the grid voltage. Upon the axes representing the anode voltage, the grid voltage and the third grid or anode current the author constructs and gives illustrations of the characteristic surfaces of the triode. Finally, he discusses the problem of directive reception. The perfecting of high-power amplifiers has had the important result of making possible the directive reception of distant stations by small antenna. For instance, it has been possible to receive transatlantic signals in England with a small frame aerial a yard square and to determine its direction by rotating the frame about a vertical axis. False directions are, however, obtained during the sunrise and sunset periods, and it has been suggested that much of the directional error might arise from the rotation of the plane of polarization of the signal-bearing waves by reflection of the non-level portion of the heavy-side layer between the sending and receiving stations. It has, moreover, been abundantly proved that rays bending round the globe follow a curved trajectory resembling that of a projectile. In the daytime these magnetic rays have their force horizontal, but if at night the plane of polarization is rotated in any manner, the apparent direction of the source of radiation would become erroneous. The cause of the rotation of the plane of polarization is still a problem. It is evident that the earth's magnetic field will introduce obliquity into the motions of ions propelled by the electric force of the waves. Waves passing over any particular ion impart to it a to-and-fro motion of the same period as that of the waves, but lagging behind their electric force by about a quarter of a period. An ion moving in the earth magnetic field is deflected by that field and acquires an oblique component of velocity while a calculation shows that a rotation such as is demanded by the observed facts of directive wireless telegraphy might be furnished by the passage of waves through a space containing free electrons.

Further, the longer the wave the greater the directional error should be, and if a station transmits a group of slightly differing wave-lengths a kind of spectrum analysis could be performed by a radio-goniometer. The information gained from observations made with directive aerials must be combined with the knowledge furnished by an analysis of the records of magnetic variations and magnetic storms. It would seem that the diurnal variations of the range of wireless signals must be due to the kind of ionization of gases familiar in laboratory work with X-rays and the γ-rays from radium.—*Electrician* (London), December, 1920, pp. 678-680.

SOME RECENT GERMAN WELDING MACHINES

The *Engineering Progress* for September, 1920, describes a *stepping* roller welding machine which works on the principle of resistance welding. The older types of seam welding machines used to work with uniformly turning welding rolls in such a manner that an alternating current of low pressure and high amperage was transformed in the machine in passing from one roller to the other through the path to be welded. The material to be welded was inserted between the two rollers. The resistance which is offered to the passage of the current at the surface of the contact of the two pieces of material to be welded together converts the electric current into heat. The material is brought up to welding temperature and is joined together by the pressure of the rollers. By the uniform rotation of the roller the seam passing between the two rollers is welded together in one uninterrupted operation. The working speed is comparatively high, yet this rapid process has not been introduced to any great extent: it was too sensitive even against slight impurities of the welding surfaces and small obstacles in the rotation of the rollers and for

this reason it has in fact never been possible to assure with this process a permanently satisfactory operation.

The stepping rollers process placed on the market by the Gesellschaft für Elektrotechnische Industrie in Berlin has remedied the above-mentioned faults. With this new process the welding rollers do not turn uniformly, but after a partial turning movement they are arrested for a moment in order to proceed with another partial turning movement. Such partial turning movements or steps are made by the roller at the rate of 10-800 per minute, varying according to the thickness of the material to be welded. At every partial rotation a distance of from 1/16 to ½ inch is covered by the roller, this distance varying with the thickness of the material. The welding current is coupled to the movement of the roller in such a manner that at the moment when the roller comes to rest, after having completed one step, the current is switched on. The part of the material below the roller at that time is heated up to welding temperature and is welded by the pressure resting upon it. Immediately afterward, the current is interrupted for a short period, the roller will keep up its pressure upon the welded part, until the latter has cooled down under the pressure and under exclusion of air to such an extent that sufficient strength is obtained to prevent the material from being torn apart by any tension in the material. This new process has shown excellent results; even sheet metal with very unclean surfaces covered with scale has been welded according to this process in a faultless and clean manner. The reliability of the operation of this new machine is claimed to be so great that it has become possible to design automatic seam welding machines on this principle up to any output. The wear of the electrodes is very small; even if the sheets are covered with scales the electrodes remain perfectly clean.

A number of electric welding machines built by the Moll Works of Chemnitz are described by T. Vaillant in *Elektrotechnische Zeitschrift* for August 19, 1920. The butt welding machine manufactured by this company contains a 75-kva. transformer with 5 step-down ratios. The ends of the pieces to be welded are clamped between cheeks that form at the same time the secondary terminals of the transformer. The cheeks are water-cooled, and can be moved toward each other during the process of welding, so as to press the welded surfaces together. The energy required for welding bars from 19 to 50 mm. in diameter ranges from .057 to 1.346 kw-hr., and the time required per weld varies for these sizes between 10.7 sec. and 143.2 sec. The water consumption is 86 liters per hour. The company also makes electric rivet heaters and machines for welding sheets and chain links.

Survey of Progress in Mechanical Engineering

Prepared Under the Auspices of the American Society of Mechanical Engineers

JUNKERS WATER EDDY BRAKE

DESCRIPTION of a water brake of the eddy type employed in the testing laboratory of Doctor Junkers for testing oil engines with a power output of the order of 1,000 horsepower. Essentially, the brake consists of the rotor A (Fig. 1) keyed on a shaft and a stator B located centrally to the shaft. The stator and rotor are provided along their periphery with finger-like attachments arranged in a certain manner, water being circulated between these attachments. If now the rotor A be set up in rotation the water between the finger-like attachments offers a resistance which converts the energy supplied by the motor into heat and this heat is in its turn

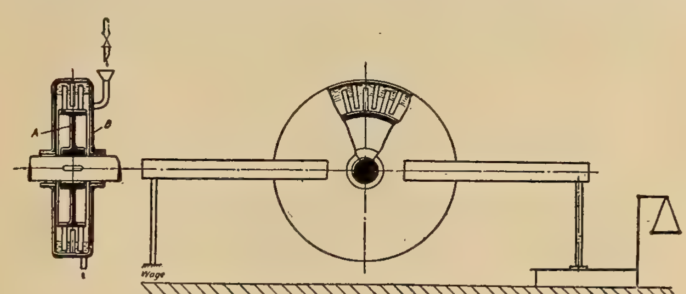


FIG. 1. JUNKERS WATER BRAKE, EDDY TYPE

carried away by the water. The brake has, therefore, no solid parts rubbing against each other. The thickness of the water rings determines the output which the brake is capable of handling and the regulation of the brake is carried out in a very simple manner by varying the level of the water rings which is done by regulating the water inlet and outlet valves. Preferably, water admission is so regulated that no steam is produced as this would make conditions in the test room unpleasant.

If water is admitted at 10 deg. cent. (50 deg. fahr.) and let out with an outlet temperature of 65 deg. cent. (149 deg. fahr.) then the brake needs 636 = 11.6 kg. of water per b. hp-hr. The brake is equally suitable for all kinds of motors, outputs and speeds. Thus the original article illustrates a brake of this type applied to the testing of an exhausting turbine of 6,400 hp. at 210 revolutions. Another illustration shows a 600-hp. Diesel motor, etc. One of the advantages claimed for this brake is that it prevents the engine from running away under any conditions whatsoever.—*Wirtshafts-Motor*, No. 9, Sept., 1920, pp. 19-20.

POWER AND FUEL FACTS

THE following figures are of great interest:

Prime movers of all kinds in U. S. (Stationary and locomotive)	100,000,000 hp.
Used at average load factor of	14 per cent
Used for average period per week	23.5 hr.
Develop per year	125 billion hp. hr.
Water power available	50,000,000 hp.
Coal (without lignite), in ground	2,500 billion tons
Petroleum, in ground	7 billion bbl.
Used for power only (locomotive and stationary) on basis of present power delivered, resources will last:	
Water power, if all developed	indefinitely
Coal used by best practice	57,000 yr.
Coal used by average practice	7,500 yr.
Petroleum (allowing 40 per cent gasoline)	9.25 yr.
Of prime movers installed:	
Steam plants, coal fired make up	8.2 per cent
Hydraulic plants, make up	8.2 per cent
Combustion engines and other types, make up	39.8 per cent
Of power developed:	
Public utilities use	42 per cent
Manufacturing plants use	28 per cent
Railroads use	30 per cent
Of 1 ton of coal in the ground	2,000 lb.
Best recovery brings to the surface	1,900 lb.
Average recovery brings to the surface	1,400 lb.
Poor recovery brings to the surface	1,000 lb.

Power to operate the coal mine takes	100 lb.
Turned into useful work at point of application:	
By best large central stations	608 lb.
By best small central station	304 lb.
By locomotices best practice	175 lb.
By small individual plants, average practice	76 lb.

Power Plant Engineering, Vol. 25, No. 1, Jan. 1, 1921.

POSSIBLE FUEL SAVINGS IN AUTOMOTIVE ENGINES

H. C. Dickinson and S. W. Sparrow

Report of tests carried out at the Bureau of Standards. The apparatus employed permitted of seeing the acceleration of the engine by means of an acceleration disk mounted on the dynamometer shaft. This was of steel 33 in. in diameter and ½ inch thick. Its inertia added to that of the dynamometer was about equal to that of a 3,500 lb. car on direct drive with a gear ratio of 5 to 1 and 32-in. wheels.

Among other things, the tests covered the influence of jacket water temperature on fuel economy. Two series of tests were

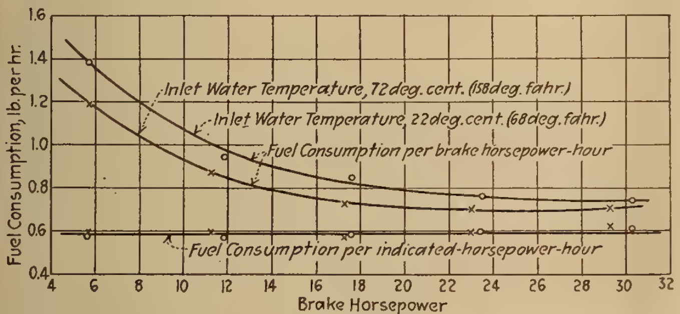


FIG. 2. CURVES SHOWING THE RELATION BETWEEN FUEL CONSUMPTION AND JACKET WATER TEMPERATURE

made; in the one the temperature of the water entering the jacket was maintained at 162 deg. fahr., and in the second at 72 deg. fahr. Runs were made at full load 0.8, 0.6, 0.4, and 0.2 of full load, with five carburetor adjustments at each throttle setting. From these results the minimum fuel consumption for each setting has been selected and plotted in Fig. 2. From this it appears that the fuel consumption per unit power based on brake horsepower is considerably higher with the cold jacket water.

It may be mentioned in this connection that tests made several years ago by J. B. Replogle have shown that a very considerable economy in fuel consumption is obtained when the temperature of water is carried to a still higher point than was used by the Bureau of Standards in its test, namely, at the boiling point.

Other tests cover the influence of intake manifold heating on acceleration and on the maximum horsepower of the engine, it having been found that heat supplied to the charge increases the maximum power of the engine.—Paper presented at the meeting of the American Petroleum Institute, Nov. 17, 1920, abstracted through *Journal of the Society of Automotive Engineers*, Vol. 8, No. 1, January, 1921, pp. 3-9.

RECORDING SPEED INDICATORS

By A. G. Newell

While the recording speed indicator might be of great service in railroad operation, as the author points out, there are many elements some of which are of psychological rather than mechanical character which have so far interfered with its useful adoption. Some operating officials are rather reluctant to set a speed restriction and require its observance at all times. Engineers who are not familiar with the working of the speed recorder are also apt to look upon it with disfavor, even though they often change their opinion after becoming familiar with it, as they realize that an instrument of this kind eliminates taking of chances by the other fellow and puts each crew on the same basis.

A speed recording device on the locomotive is of particular interest as it permits more certain and curiously enough more rapid operation over bridges in bad condition, slow track or curves. At present it is the practice of a good many foremen to place very slow limits of speed over bridges and parts of track undergoing repairs, in the expectation that enginemen would not hold their trains to the letter of the order and would, in most cases, make two or three times the speed that the order called for, with the result that enginemen obedient to the order go at speeds very much lower than is actually necessary. The correct speed can be set and maintained, however, without difficulty where recording speed indicators are used.

The experience of the El Paso and Southwestern System is described in practice. Their experiments were started in 1907 with a Flaman tachograph brought from France. This instrument gave satisfaction and in 1911 three more of the same make were applied. These four instruments met with such success that it was decided to adopt them as a standard appliance for all road engines on the system. A mechanic was sent to the factory in France and made a thorough study of the instrument. A modern shop for testing and repairing was then fitted up at the General Shops at El Paso, Texas. Since then 114 locomotives in road service have been equipped with the Flaman tachograph and there are sixteen reserve instruments on hand.

The apparatus has a speed indicating dial graduated from zero to 90, each division representing one mile in speed. A small black pointer plays over the face of the dial indicating the speed being made at all times when the engine is moving in either direction. The lower part of the case contains the speed and time recording mechanism and the recording tape, the record on the tape being made by two styles. A sample of a record is given in Fig. 3. The time recording style rises from the bottom line to the top line in a given interval, which, in various types of indicators may be either 10 or 30 min., making a sudden and vertical drop from top to bottom. The degree of inclination of the oblique lines made by the style depends on the speed being made, the greater the speed the less the inclination. During the time the engine is standing the time recording style will move up in a vertical line or a series of vertical lines, each full line from bottom to top rep-

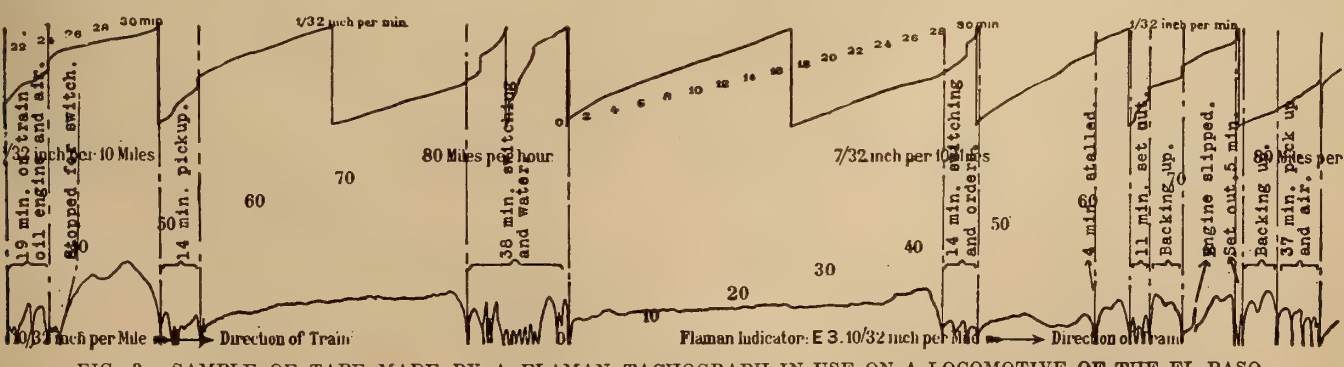


FIG. 3. SAMPLE OF TAPE MADE BY A FLAMAN TACHOGRAPH IN USE ON A LOCOMOTIVE OF THE EL PASO AND SOUTHWESTERN SYSTEM

resenting 10 or 30 minutes, depending on the tape used, and each fraction of a line its portion of time.

The mechanism of the instrument is of clockwork type and receives its motion from a series of springs which must be wound by the engineer by means of a small crank before the engine leaves the roundhouse track or at any time after the engine has stood for a period of 30 minutes or more during the trip. When the engine is moving in either direction the clockwork is wound automatically by means of transmission rods and gears, receiving its motion from a driving stud and arm attached to the right back side rod pin and will continue to run for a period of from 30 to 40 minutes after the engine has stopped.

The instrument is so arranged that tampering with it is quite difficult. The cost of the apparatus at present is said to be $270 for each instrument and $193 for applying it. The average length of time an instrument will stay in service without repairs is about four months.—*Railway Review*, Vol. 68, No. 1, Jan. 1, 1921, pp. 7-10.

REPORT ON TIDAL POWER OF THE WATER POWER RESOURCES COMMITTEE OF THE BRITISH BOARD OF TRADE

THE third interim report is particularly concerned with the question of development of tidal power in the Severn estuary.

The committee states that the importance of the project from the national standpoint cannot be easily overrated in view of the magnitude of the power involved and of the far-reaching character of the economic consequences which would follow the actual development of such a scheme if it could be carried out on sound economic lines.

From data presented one particular site on the Severn, not necessarily the best, might be rendered capable of developing tidal power representing a saving of from one and a quarter million to two and a half million tons of coal per year.

The question is to what extent can this be actually accomplished. In the Severn estuary the tidal amplitude is large, the configuration of the estuary is well suited to the purpose in view. The physical characteristics of the land in the vicinity are such as to facilitate the construction of a high level storage reservoir, while the adjoining industrial district is one in which the power requirements are already large and the power supply is likely to be absorbed completely for industrial purposes.

In view of this fact, the subcommittee composed of Sir Philip Dawson and Prof. A. H. Gibson was appointed for the purpose of a preliminary examination of the subject. While this subcommittee has not been able to secure any definite statement of opinion from the leading manufacturers of water turbines and electric generators and in a position to recommend the Severn scheme as a practical undertaking, its members came to the unanimous agreement that it certainly cannot be dismissed as impractical and that the further and more detailed technical inquiry into the subject of tidal power is amply justified and should be initiated without delay.

It is therefore proposed to appoint a larger committee for a more careful study of the problem and an intensive program of investigation for this committee is proposed.

What appears to be one of the greatest difficulties in the way of tidal power development is due to the intermittent character of the service which such a development can give. The report comes, therefore, to the conclusion that if an electrochemical, electrothermal or other process were devised capable of absorbing an intermittent power supply subject to such variations as are inherent in tidal power generation, the commercial value of tidal power would be greatly increased. Otherwise it would be necessary to provide means for providing the intermittent output into a continuous supply more or less constant throughout the working period and such conversion can be accomplished only at the expense of overall efficiency.—Abstracted through *The Engineer*, Vol. 130, No. 3390, Dec. 17, 1920, pp. 614-615.

AN EXPERIMENT WITH REST PAUSES

By J. LOVEDAY

PART of a report of the Industrial Fatigue Research Board. While the experiment covered a period of little more than six months, it is of considerable interest. The experiment was carried out at the plant of a firm having two factories, in one of which shoes were manufactured and in the other heels and stiffeners only.

In the stiffener and heel works all the employees with the exception of the foremen were women, the working hours in 1918 being 46 per week. In 1918 the firm found itself confronted with the problem of increasing output without adding new machinery, owing to the extreme difficulty of obtaining machinery at that time. The difficulty arose particularly in the press-room where the leather is cut into pieces of the shape required by a mechanical press working upon a heavy knife of the requisite form. The presses are of two types, single and double, a double press being a bench with a press at either end. The operation demands skill and care, flaws in the leather must be avoided, and the skin cut with as little waste as possible. The problem has been successfully solved by the adoption of the following plan:

It was determined to make the experiment of working the double pressed with a team of three girls, each operative working 40 minutes in each hour and resting 20 minutes, instead of with two girls working continuously throughout the day. It was hoped thus to increase the output of the machine, and how fully this hope has been justified by results will be seen from the figures below. The experiment was begun in January, 1919, on a machine with results so favorable that in July six double presses were being operated on this system. A comfortable and attractively furnished rest room, quiet and restful in color, has been provided, and but for the difficulty of arranging for further rest rooms, a difficulty which can only be overcome by building, the plan would already have been greatly extended. There the girls, when they come down from work, are free to rest or to occupy themselves with crochet, knitting, etc., as they may desire.

Six girls, one for each machine, go to the rest room on arrival at the factory in the morning, and do not start work until 8 o'clock; from then onward the period of rest is 20 minutes in the hour throughout the day. Those whose turn it is to rest at 11:40 a. m., and at the corresponding period in the evening, are allowed to go home. The experiment was constituted with the consent of the operatives after thorough explanation, and, though somewhat skeptical at first as to success, they were willing to give it a trial.

The operatives are paid by day rate plus a bonus on output. This bonus is computed by calculating the weekly output of the press and dividing it into three equal parts, so that the three members of each team receive an equal bonus, proportional to the amount of work done during the week.

With the new arrangement a total increase of output on the six presses was obtained amounting to over 44 per cent and this very high figure is attained with the reduction of the working hours of the individual operatives by one-third, and without the addition of new machines. Sufficient data are not available to draw any accurate conclusions as to the actual increase or decrease in output of individual workers, but it would appear that there was such an increase. In particular, it appears that a change benefited specially the comparatively unskilled and the less robust workers.

As regards the effect on workers, it is stated that at first the girls did not believe the scheme would prove successful, and did not believe they could put out enough in such short hours. Experience, however, reconciled them to the system and none of them at the time of the investigation desired to return to the former hours. This was particularly so in the case of the weaker and less highly skilled girls.—*Report No. 10 of the Industrial Fatigue Research Board*, (Great Britain), abstracted through *Engineering and Industrial Management*, Vol. 4 (New Series), No. 23, Dec. 2, 1920, pp. 716-718.

Progress in Mining and Metallurgy

Abstracts of Papers and Recent Articles

Prepared Under the Auspices of the American Institute of Mining and Metallurgical Engineers

DUST-VENTILATION STUDIES IN METAL MINES

By D. Harrington

Investigations in mines of foreign countries, as well as of the United States, prove that breathing air containing minutely divided dusts is likely to be harmful to the health. The most harmful dust is apparently that which is practically insoluble and breaks into minute particles with sharp, cutting edges. Free silica, such as quartz, flint, etc., has these harmful properties to a great degree and is thought to be the most harmful of dusts. Silicates are also insoluble and some of them break into fine particles with cutting edges, but they do not appear to be as harmful as quartz. The harmful dust, in general, is smaller than 10 microns, or about 1/2500 in. Inasmuch as probably much over 50 per cent of all metal mining in the United States is in siliceous material, the importance of the dust problem is manifest.

While fine siliceous dust is likely to be dangerous, especially when the dust is free, such as quartz, a mine working in quartz material may have especially dusty conditions and the employees be apparently immune to diseases of the respiratory tract.

1. The quartz may be in a condition of partial alteration, due to heat, pressure, or chemical solutions, and bear somewhat the same relationship to unaltered quartz, as to sharpness and hardness, as would decayed oak to the original dry hard material.

2. The quartz dust may be associated with some other dust so that the harmful features of quartz dust (sharpness and insolubility) are neutralized or eliminated. The latter is essentially the adsorption theory advanced by Haldane.

3. A mine having dry siliceous material drilled dry, even using a large percentage of upper holes and hence producing the maximum amount of fine dust, may be comparatively harmless to the health of workers if sufficient air currents are provided to sweep the dust away as it is formed, the workers keeping as much as possible to the fresh-air side of the drill. In general, compressed-air blowers (supplying about 100 cu. ft. of air per min.) are inadequate to ventilate these dusty places properly so definite means, such as small fans and tubing, must be provided to cause a current of 1,000 or more cu. ft. (28 cu. m.) per min. to pass the worker and either take away the dangerous fine dust from the working place or reduce the dust content of the air at the working place below the danger point.

While siliceous dust is probably the most harmful, it is the opinion of the writer that all dusts, especially those insoluble in water (and some that are soluble) are likely to be ultimately harmful to the health of breathers; this applies to coal dust as well as to strictly mineral dusts.

The writer cannot concur in the recently advocated policy of introducing foreign dusts to neutralize dusts known to be dangerous to health. In metal mines, dust must be removed or its formation prevented. The introduction into coal mines of suitably chosen stone dust to prevent explosions is commendable because of the immensely greater menace of explosions than of any probable health feature in rock dust, provided the latter is carefully selected.

The dust menace in metal mines is at its worst:

1. To workers in comparatively dry places in siliceous ore in dry drilling of upper holes in unventilated places, especially if the air is above 80° F. (27° C.) and 85 per cent relative humidity.

2. To workers in comparatively cool dry places where air is not kept moving by ventilation.

3. To workers in dry mines, or places, where blasting is done while men are on shift.

The principal measures for the prevention or removal of dust in metal mines are as follows:

1. Eliminate dry drilling.

2. As far as possible, blasting when men are on shift should be avoided.

3. Dusty places, such as manways, chutes, loading or dumping places, downcast haulage shafts, etc., should be kept damp by permanent water sprays.

4. The introduction of large quantities of water by the use of wet drills, sprinkling, etc., will cause the underground air to be practically saturated with moisture, a condition generally held to be harmful.

5. Where formation of dust cannot be prevented, one of the most efficient methods of removal is to sweep the dust-producing places with 1,000, or more, cu. ft. of air per min.—To be presented at the New York Meeting of the Amer. Inst. of Min. and Met. Eng., Feb., 1921.

THE HEALTH OF THE UNDERGROUND WORKER

By A. J. Lanza

Industrial medicine bids fair to become one of the most important and highly developed branches of medical science. Mining companies, even in remote district, have developed large and efficient medical organizations that comprise the best types of physicians and surgeons.

The mine doctor who never goes underground must remain ignorant of the factors causing many of the disorders he treats as well as miss the best opportunity of gaining the respect and coöperation of the men he serves.

It is impossible to define the exact organization of a medical service for a mining community or company. Local conditions vary greatly, as does the responsibility of the company to its employees. If the doctor and the company are imbued with the idea that high-grade surgical and medical service is possible, desirable, and profitable and if the doctor will endeavor to apply the principles of scientific medicine, including prevention as well as cure, any type of medical organization suitable to the local needs will be a success. Where these ideals are not recognized, the most elaborate medical machinery will not give satisfactory results.

In mining, rescue and first aid work have been developed to a higher point than in probably any other industry.

The men should be urged and encouraged to go to the company dispensary or hospital for minor ailments, such as coughs, colds, and the like.

Industrial workers, especially foreigners, often will not call in a physician until sever illness compels them.

A visiting nurse, or nurses, is a valuable adjunct to any medical service. Such a nurse will call on men absent on account of sickness, see that the sick are properly cared for, help the family in time of stress, and be a potent factor in promoting public-health work. Tact and discretion are absolutely necessary for a visiting nurse, who should be responsible to the doctor and should not be diverted from her proper function.

It would be absurd for industry to take the stand that only those can work who are able to pass a fairly rigid physical examination, but it is fair to assume that no man has a right to work at a specific occupation where, as a result of his physical condition, he might be a source of danger to himself, his employers, or his fellow employees. The physical examination makes it possible to recognize and record physical defects

and thus prevent their being charged against the company in the event of an accident. Certain employees such as hoist ing engineers, cage tenders, rescue men, fire crews, shot firers, and men working on underground haulage systems should be examined not only when hired but at stated periods.

The successful conservation of the miner's health depends on three basic principles: He must be physically adapted to his work, he must be guarded from undue hazard while at his work, and he must receive skilled and prompt attention when injured or ill.—To be presented at the New York Meeting Feb., 1921.

THE FUEL SUPPLY OF THE WORLD

By L. P. Breckenridge

At the Annual meeting of the American Society of Mechanical Engineers, in December, 1920, the sessions devoted to fuel and its conservation aroused great interest. Among the papers presented was one by Mr. Breckenridge on the fuel supply of the world, from which we have excerpted the following paragraphs, reprinted from the January number of *Mechanical Engineering*:

HOW TO PREVENT WASTE OF COAL

1. Extend as rapidly as possible improved methods of mining coal. At present one-third the bituminous and one-half the anthracite coal is left in the mine under such conditions that recovery is practically impossible.

2. Extend improved methods of "preparation" of coal at the mines. A premium might well be allowed for well-prepared coal, or a penalty imposed for impure coal.

3. Reduce the hazards of coal mining. For every 1,000,000 tons of coal mined there are between four and five fatalities.

4. Operate the mines a maximum number of days each year. Mines are operated from 200 to 240 days in one year. Lost time is due to three principal causes: shortage of cars, shortage of labor or strikes, and mine disability.

5. Utilize a larger amount of the mine waste. Briqueted fuel, pulverized fuel and electricity from mine waste are all possible of successful development.

6. Increase the use of byproduct coke ovens. The byproducts wasted by beehive coking are equal to fully 600 lb. of coal per ton of coke produced. Increase the use of domestic coke from the local gas plant.

7. Extend the use of blast-furnace gas for power generation. Much progress has recently been made. It will require coöperative effort to utilize fully the power which might be made from blast-furnace gas.

8. Extend the use of the gas producer, the gas engine and the heavy-oil engine for power generation, more especially where electrical energy is not available. Develop the lignite fields—by power from gas producers—and briqueted fuel for domestic use.

9. Extend waterpower development. Hydroelectric power often combined with steam power offers large possibilities for saving coal. It will require comprehensive expert study before any new development can be undertaken, or satisfactory financial returns may not be possible.

10. Extend very generally the best-known performance of locomotives. The better locomotives of 1920 use only two-thirds of the coal required 20 years ago to do the same work. Much saving should be expected in the operation of steam locomotives. Electrification will save coal where water power is conveniently available. Instructions to firemen should be given and followed up even more carefully than in the past.

11. Encourage the tendency of the small industrial plant to purchase its power. The best coal is often sent to the small plant. Small plants like individuals should be examined by experts and all reasonable effort made to conserve fuel. Correct equipment and correct methods of operation would save 20 to 25 per cent of the coal used in industrial plants. It is the coal saved by the industries that will set free transportation facilities sorely needed for other purposes than hauling coal. One-third of the railroad tonnage of this country is coal.

12. Furnish homes and public buildings with correct and simple instructions for operating the furnace, heating, boiler and stove. This involves using fuel with suitable equipment for burning it. This should result in saving from 10 to 15 per cent of the domestic coal consumed.

Table 1.—*Total Coal Reserve of the World in Millions of Tons*

X. INTERNATIONAL GEOLOGICAL CONGRESS, CANADA, 1913

EASTERN HEMISPHERE

Europe		Africa	
Germany	423,356	South Africa	56,200
Great Britain and Ireland	189,533	All others	1,639
Russia (in Europe)	60,106		
Austria	53,876		
France	17,583		
Belgium	11,000		
All others	28,736		
Total for Europe	784,190	Total for Africa	57,839
Asia		Oceania	
China	995,587	Australia	165,572
Siberia	173,879	New Zealand	3,386
India	79,001	All other Islands	1,452
Indo-China	20,002		
Japan	7,970		
All others	3,147		
Total for Asia	1,279,586	Total for Oceania	170,410
Total for Eastern Hemisphere	2,292,025		

WESTERN HEMISPHERE

North America		South America	
United States	3,838,657	Colombia	27,000
Canada	1,234,269	Chili	3,048
All others (including Central America)	505	Peru	2,039
		All others	10
Total for North America	5,073,431	Total for South America	32,097
Total for Western Hemisphere	5,105,528		
Total reserve for the world	7,397,553		

Table 2.—*Annual Production of Coal in the United States*

	Millions of Short Tons			Millions of Short Tons	
Year	Anthracite	Bituminous	Year	Anthracite	Bituminous
1880	30	44	1915	86	435
1890	42	110	1916	87	460
1900	60	210	1917	88	500
1905	70	310	1918	87	566
1910	82	420	1919	86	420
1914	84	420	1920	84	(510)?

Table 3.—*One Year's Fuel Requirements of the United States and Their Coal Equivalent* (13,000 B.t.u.)

Kind of Fuel	One Year's Fuel Consumption	Approx. Coal Equivalent (Tons-2,000 Lb.)	Conversion Factors
(1) Peat	25 thousand tons	12,500	2 tons = 1 ton coal
(2) Natural gas	800 billion cu. ft.	27,000,000	30,000 cu. ft. = 1 ton coal
(3) Wood	80 million cords	40,000,000	2 cords = 1 ton coal
(4) Water power	7.5 million developed water horsepower	55,000,000	33 per cent load factor 5 lb. coal per hp.
(5) Petroleum	360 million barrels	100,000,000	3.6 bbl. = 1 ton coal
(6) Coal	650 million tons	650,000,000	
Total		872,012,500	

13. Extend the custom of coal storage. The facts relating

to this important practice are now available. Coal may be safely stored and the load curve on the mining industry may be much improved. The coal should be stored at or near its point of consumption.

14. Extend electrification. The full use of electrical energy offers the most promising means of saving coal. Conservation by coöperation of water power, steam power and electricity opens up large possibilities for saving coal, capital and labor. This is contemplated by the superpower plan now being investigated by the Department of the Interior and a report is in preparation by an engineering staff which will set forth the facts as to: (*a*) Needs for superpower, (*b*) characteristics of an installation, (*c*) location of suitable superpower lines, (*d*) estimated costs, (*e*) estimated economies and other details.

Correspondence

The editor is not responsible for statements made in the correspondence column. Anonymous communications cannot be considered, but the names of correspondents will be withheld when so desired.

THE CENTER OF THE EARTH

To the Editor of the Scientific American Monthly:

May I venture to add to your "center of our earth" discussions? We assume that the center of the earth is at great temperature and compressed to great density. This mass comprises all but a less than orange peel proportion of crust. As the center cools it contracts, as the exterior disintegrates it expands. Both actions make the crust a poor fit. That it crumples and folds is evidenced in the strata of mountain ranges and coast lines. As it crumples there is a local shifting to a new equilibrium, with its accompanying quake or quakes, just as ice moves in a glacier, readjusting pressures by regelation, so the unaccommodated masses of the earth's interior, as the pressure increases, will liquefy and burrow to a position of readjusted pressure, leaving their traces in dikes, pipes, laccoliths, in case they do not reach the surface. In case the regelated magma reaches the surface it is a question of the heat and pressure still retained as to whether it is an explosive or a more or less quiet flowing lava stream. If the contained energy of heat and pressure is sufficient there is no reason whatever why the mass itself should not spring into the vapor of its own constituents later to be sublimated into the powder which circled the globe after Krokatoa or that buried Pompeii and Katmai. The drive of exploding water is not necessary to volcanic action.

New York. George N. Cole.

"IS THE EARTH EXPANDING OR CONTRACTING?"

To the Editor of the Scientific American Monthly:

There appeared in the July issue of the Scientific American Monthly, an article by Hiram W. Hixon, entitled "Is the Earth Expanding or Contracting?" It was accompanied by a letter by the same author criticising an article on "The Ballistics of Volcanoes," by M. Belot, which had appeared some time previous.

I wish to take issue with Mr. Hixon in many of his statements. Much of his evidence could equally well be used to support theories contrary to his own; and he overlooks evidence which can only be read contrary to his theory.

Speaking of the elevation of lands and of mountain ranges above the sea, he says, "The contraction hypothesis is incompetent to explain these changes of altitude because of lack of strength in the crust. . ." He tacitly assumes that in order to form elevations and depressions by contraction of the interior, the crust would at the elevated areas, have to stand by its own strength, *entirely* without support. In other words, he tactily assumes a *solid* contracting core, altogether separate from a solid crust. This solid, non-conforming interior which he evidently has in mind is the direct contrary of the fluid interior which he postulates in other places in his article. Both cannot concurrently be true. If the fluid interior be postulated, then that very lack of strength in the crust which he mentions would cause partial collapse of the crust until the fluid had been forced up to support the higher parts of the crust sufficiently to maintain equilibrium. If the crust had greater strength, we would expect fewer irregularities.

In his statement that the great predominance of "expansion faults" over "compression faults," proves that the earth is expanding, he fails to take all of the data into consideration. He does not take into account the fact that the earth may be contracting while its crust is expanding to take care of the greater roughness of the surface. He also fails to take into account the fact that even if the earth were contracting much faster than it is, still the "expansion type" of fault would be the normal, by reason of the fact that the co-efficient of friction of rock against rock is greater than unity; and unless the angle of fault with the plane of compressive forces, were very small, bodily crushing of the rock would take place before faulting through compression only. In other words, the predominance of normal faults proves nothing.

Mr. Hixon assumes that the earth was in the beginning a mass of incandescent gas; that the gas cooled superficially and solidified directly forming a crust.

It has been demonstrated in our laboratories that our common gases have average molecular velocities approaching the velocity of escape from the earth at the earth's surface. Individual molecules probably frequently exceed that velocity and would escape, were their paths not obstructed by slowly moving molecules. If the whole earth, including the crust, were gaseous, the diameter of the mass would be some thousands of miles greater than it now is, with a resultant very much diminished velocity of escape at the surface of the mass. Mr. Hixon's assumption of incandescence also involves much greater molecular velocities than those which hold at ordinary temperatures.

The combined result of these two conditions would be a very rapid dissipation of the gas at the exterior of the mass into space. This tendency would be enhanced as the central mass became smaller through loss of the dissipated gas, by a correspondingly weakened central gravitation. And while it is also true that reduction of pressure and consequent expansion and cooling of the interior gases would have some counteracting influence, this influence would not be sufficient to hinder dissipation since molecular velocities decrease only proportionately to the square root of the pressure or temperature.

And even assuming that parts of the gas did come into proper conditions for liquefaction or solidification, and that this took place, the solidified particles would immediately by their greater density fall down into the hotter mass below where they would be re-volatilized, and their place on the surface taken by more hot gas from below. The net result of this would be a state akin to ebullition which would keep the temperature uniformly distributed and help further dissipation. Indeed, we would expect storms of a thousand times greater intensity than we have in the earth today, and which would rival the sun's storms in violence. It is, of course, unreasonable to suppose that the whole crust solidified instantly and was thus prevented from falling into the central gas by its own structural strength as a dome.

I have not space to go into it further here, but believe I have made it sufficiently evident that a body of incandescent gas of the order of mass of the earth would not be stable, but would dissipate into space. And we can only conclude that, whatever its original condition, the earth was not originally incandescent gas.

I will say in passing that a body of gas of much larger mass than that of the earth would have a relatively much

greater centralizing influence and would not dissipate. The proof is too lengthy to give here, but I believe that anyone who has the requisite data and will go into it will be readily convinced that such is the case. Such a mass is the sun.

Now as to Mr. Hixon's hypothesis that the interior of the earth is gaseous and is expanding on solidifying:

I take from *Young's General Astronomy*:

	Mass	*Density*
Earth	1.0	5.55
Jupiter	317.7	1.32
Saturn	94.8	0.72
Sun	332,000	1.39

It will be noted that the earth has the smallest mass of the bodies listed, but the greatest density. Yet we know that the earth has the same general composition, at least, as the sun.

Were the earth and the sun both gas, the sun would have the greater density. Hence we are forced to the conclusion that both are in the main solid, or that the earth is solid and the sun gaseous. I purposely neglect to take into account the earth's crust as of relatively too small amount to influence this comparison. I believe that it is pretty plain that the hypothesis of a gaseous earth either past or present is untenable.

I will say that my own theory is that the sun and all planets are centrally solid; and that the low average density in those bodies of greater mass is explained simply by the fact that their great masses are able to hold a relatively much deeper atmosphere, which renders their apparent diameters much greater and correspondingly reduces the apparent mean density. This theory explains many facts not otherwise explainable. And if I am asked what becomes of the law of critical temperatures, I will say that either interior temperatures of the heavenly bodies are lower than they are supposed to be, or that the law of critical temperatures breaks down under the terrific pressures involved. Either assumption would be justifiable in the absence of direct experimental proof. Van der Waals' equation holds true only up to certain limits within experiment.

Mr. Hixson's criticism of Chamberlain's planetesimal postulate on the ground that the moon's craters show that the moon has once been molten, lacks connection.

We should certainly expect under Chamberlain's postulate that the moon at one time was molten—superficially at least. The heat of bombardment of planetesimal matter would be more than sufficient to account for that molten condition. In other words, a past molten condition of the surface of the moon neither proves nor disproves Chamberlain's postulate.

How does Mr. Hixon's theory account for a molten moon coexistent with an earth which he postulates passed directly from the gaseous to the solid condition?

Regarding the process of forming a solid crust, he tells us that as the mass of the outer surface falls below the critical temperatures of some of its constituents, they pass directly from the gaseous to the solid condition because gravitational compression has *raised the fusing point to the critical temperature.*

He has made here the double assumption: 1. That the cooled gases are on the outer surface of the gaseous core, and 2. That they are under gravitational compression sufficient to raise the fusing point to the critical temperature. Now fusing points rise very slowly under pressure. To be under sufficient pressure to have its fusing point raised to the degree he supposes would require that the gas be well down toward the center of the mass, below the cooling zone. This is contrary to his first assumption that it is on the surface. In other words, this direct passage from gaseous to solid condition is impossible so far as the ordinary substances of the earth's crust are concerned.

In his computations of the amount of lava required to furnish heat for volcanoes, geysers, etc., Mr. Hixon again neglects to take all possibilities into consideration. His arbitrary assumption of a cooling range of 750° seems very low. He fails to consider the possibility that radio activity or chemical action may produce heat. It is well known that many hot springs contain helium, a by-product of radio activity. The hot springs of Colorado are near known mines of radio-active metals. There are hundreds of chemical reactions which may be taking place deep underground which may be evolving heat in inconceivable quantities. Indeed, as most volcanic disturbances are near the sea coast, it is possible that the salts of sea water may be a catalytic agent, forwarding some of these reactions. There is an unlimited number of possibilities.

He says further: "As a result of rock flowage without melting, all cavities are closed at a depth of a mile or less. . . ." I see no warrant for this assertion. A temperature of 170° F., which is above that reached at a mile in depth, is not sufficient to reduce the rigidity of ordinary rocks sufficiently to permit flowing, even under the 7,000 pounds per sq. in. pressure which that depth entails. Building stones have been tested without failure to more than twice that pressure at ordinary temperatures. The refractories and other substances which are frequently stressed while under heat and are closely allied to the rocks in composition and structure do not begin to lose their rigidity until much higher temperatures than 170° Fahr. are reached. Is it then reasonable to suppose that the rocks would do so? Or if Mr. Hixon's assumption is correct, why have not the walls of the Grand Canyon, which is more than a mile and a half deep, flowed together and closed the canyon?

It has been authoritatively estimated that rock flowage does not take place until a depth of ten to twelve miles is reached. Until we have evidence to the contrary we may safely assume that cavities can exist, and surface water can penetrate to that depth.

Regarding his remark on the unreasonableness of steam generated *at sea level* forcing lava through a cone 4,000 ft. high,—I would call his attention to the fact that all theories of volcanic action assume that the steam is generated at a considerable *depth below sea level.* My idea of what very likely happens is that steam generated at a considerable depth first bursts through a weak point in the crust, forming a cone of ejected matter, and leaving a more or less open tube which serves as an easy vent for future activity. After that, the action is a good deal like that of the common air lift pump, which blows water to great heights above a source of supply by the simple expedient of introducing compressed air at the bottom of a pipe, one end of which is submerged.

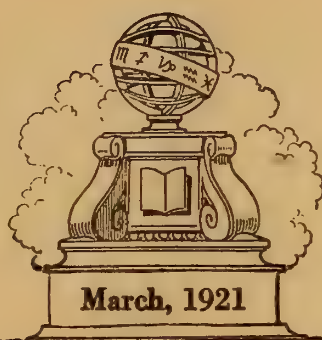
There are a number of other points in Mr. Hixon's article which I might equally well criticise, but I believe I have said enough to show that his theory will not stand the test of reason in the light of known facts; and that M. Belot's hypothesis, supported as it is by experiment, has much the greater weight of probability with it.

New York, N. Y. LEO G. HALL.

"THE PATH OF A SHELL"

IN the December issue of the SCIENTIFIC AMERICAN MONTHLY we published an article by Waldemar Noll entitled "The Path of a Shell." A more technical article on the same subject and by the same author appeared in the *Monthly Weather Review* of December, 1919, page 868. To illustrate our article we reproduced a diagram appearing in the *Monthly Weather Review*. We regret to state through an oversight on our part, we failed to state the source of the diagram and acknowledge our indebtedness to the *Monthly Weather Review* for the use of the illustration.

SCIENTIFIC AMERICAN MONTHLY



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PSYCHOLOGICAL EXAMINATIONS—THE ORIENTATION TEST FOR AVIATORS, THE SUBJECT IS REVOLVED AND TRIES TO TELL AT WHAT POINT HE STOPS (SEE PAGE 205)

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A NATIONAL SURVEY OF WASTE

When the plan was first suggested of forming a great national federation of professional engineers, there were critics a-plenty, who, despite the aid rendered to the Government by organized engineering during the war, could see no great benefit either to the public or the engineers themselves from such a federation.

The federation has only just been formed, but it is already beginning to function and has mapped out a program of service in many directions. However, one special service has been initiated which must dispel any lingering doubts as to the enormous value to the nation of this huge organization. At the convention in Syracuse last month, Herbert Hoover, President of the Federation, announced the appointment of a committee on elimination of waste in industry. This committee is to study the whole nation, as if it were a single industrial organism, in order to discover economic weaknesses; in other words, it is to make a "great national assay of waste." The task that has been set before this committee is a stupendous one and most intricate in its ramifications, but with the coöperation of between one hundred thousand and two hundred thousand professional engineers enrolled in the Federation it can be carried to a successful conclusion.

A preliminary survey has already been made of the principal elements that contribute to production waste, and lines of action have been mapped out.

The outstanding problem at the present moment is unemployment. Three million idle men are walking the streets today. The situation is a serious, but not a permanent one. We knew from past experience that these men will eventually find employment again and we shall rise on the crest of another wave of prosperity. But why should we have such waves? Why should there be periods of industrial depression? In some lines of work periods of unemployment are of annual or seasonal frequency. The most glaring example is the coal industry. Because of the habit of producing only upon demand and closing down the mines during slack periods instead of laying up stores for future demands, miners find themselves out of work thirty per cent of the time; in other words, thirty per cent more men are employed than are needed to carry on this class of work if it were distributed uniformly throughout the year. It will not be the aim of the committee to reduce employment, but rather to distribute labor to better advantage. There is no thought of appointing an individual or establishing a commission which may autocratically order men from one field of industry to another, but so to stabilize the industries asto retard if not eliminate fluctuations in production, and this calls for nation-wide coöperation.

Abnormal conditions usually spell waste. Prosperity does not necessarily indicate efficiency—quite the contrary. When the demand for products exceeds the supply of men capable of producing them the output per man usually falls far below the normal. When factory wheels are humming and working overtime incompetent men and misfits are employed, under the urge of necessity, and immediately there is a reaction upon the competent and skilled men, resulting in a lowering of the quality if not of the quantity of their product, in the wake of which there is unrest, a large labor turnover, and labor conflicts, all of which represent serious wastes. On the other hand when demands for labor fall off the efficiency of those individuals who remain at work mounts higher, but the efficiency of labor as a class falls off because of the large proportion of men without employment and the net result to the nation is a loss.

The object of the committee is not to limit but to regulate or direct production. As Mr. Hoover put it "if we could attune the whole industrial machine to the highest pitch, agriculture as well as manufacture, an increase in production would mean a directly increasing standard of living. When ten men or one hundred million men divide their united output, they can by doubling their output have twice the amount to divide. The problem of doubling the output is to direct it to commodities or services that they can use. There is no limit to the increase of living standards, except limitations of human strain, scientific discovery, mechanical invention and natural resources."

It is very evident that we are not utilizing our industrial resources to their fullest extent. In the year 1918 we produced twenty per cent more commodities than we are producing today, despite the fact that twenty per cent of our manpower was withdrawn for service in the army. It is estimated that we could produce thirty or forty per cent more if all our forces were properly synchronized.

Labor problems are by no means the only ones that will occupy the attention of the committee. Wastes of all kinds will be sought out wherever they may be found. The aim will be not merely to discover and classify these wastes but to offer suggestive criticism looking toward a remedy of unfavorable conditions, to the end that the whole nation may employ its entire resources to the very best advantage.

DIAMETER OF BETELGEUSE

A note received from Prof. George E. Hale of Mt. Wilson Observatory gives the angular diameter of Alpha Orionis as 0."046 instead of 0."045 as stated on page 104 of our February issue. This measurement was made by Mr. Pease of the Mt. Wilson Observatory staff. If the parallax of the star is 0."018, which is a measure that some astronomers believe to be more nearly correct than the figure 0."015, the linear diameter of the star works out to about 240 million miles.

The Quest of the Absolute

An Essay on Modern Developments in Theoretical Physics

By "Aurelius" (Dr. Francis D. Murnaghan, Baltimore)

It was a foregone conclusion that among the essays submitted in competition for the Einstein prize there would be a good number of the highest order of scientific merit, which would nevertheless be eliminated from final consideration by their failure to measure up—or perhaps we should say, measure down—to the standard of intelligibility of the general reader, as this standard was interpreted by the Judges. If the question had been put to us thus baldly in advance, we should doubtless have conceded the possibility that among the essays thus adjudged to be over the head of the audience to which they were supposed to be directed, there would be one standing out above its fellows quite as unmistakably as the winning essay could ever hope to stand out among those that really hit the mark of simplicity and freedom from technical matter.

Whether this was to be anticipated or not, it represents what happened. The Judges and the Einstein Editor have no hesitation in pronouncing the essay of Dr. Murnaghan, presented herewith, to be, for the man who is equipped to read it with full understanding, altogether the most illuminating of the essays submitted in the contest, if not indeed the most successful discussion of comparable length that has appeared anywhere. The Judges were agreed that Dr. Murnaghan's essay was of doubtful value before a general audience, and that in the presence of an essay such as Mr. Bolton's appeared to be it could not properly claim the prize; but it is so very good of its kind that they clung to the last moment to the possibility of its being the best, and only allowed it to be eliminated from their consideration after the most searching examination of Mr. Bolton's work had shown that it was all it seemed to be.

This criticism of Dr. Murnaghan's work makes it plain that it demands publication, and equally plain that the place for it is here, rather than in the Scientific American *proper. By all means it deserves the distinction of being the first of the competing essays to appear in the* Scientific American Monthly, *and we hasten to give it this distinction.*—Editor.

We shall discuss the more important aspects of the theory popularly known as the "Einstein Theory of Gravitation" and shall try to show clearly that this theory is a natural outcome of ideas long held by physicists in general. These ideas are:

(a) The impossibility of "action at a distance;" in other words we find an instinctive repugnance to admit that one body can affect another, remote from it, instantaneously and without the existence of an intervening medium.

(b) The independence of natural, *i.e.*, physical, laws of their mathematical mode of expression. Thus when an equation is written down as the expression of a physical law it must be satisfied, no matter what units we choose in order to measure the quantities occurring in the equation. As our physics teacher used to say "the expression of the law must have in every term *the same dimensions*." More than this the choice of the quantities used to express the law—if there be a choice open—must have no effect on its correctness. As we were told—"all physical laws are capable of expression as relations between vectors or else as relations between magnitudes of the same dimensions." We shall hope to make this clearer in its proper place in the essay, as its obvious generalization is Einstein's cardinal principle of relativity.

The measurements which an experimental physicist makes are always the expression of a coincidence of two points in space at the same time. If we ask such an experimenter what he means by a *point in space* he tells us that, for him, the term has no meaning until he has a material body with reference to which he can locate the point by measurements; in general it requires *three* measurements and he expresses this by saying that space has *three* dimensions. He measures his distance, as a rule, parallel to three mutually perpendicular lines fixed in the material body—a Cartesian reference-frame so-called. So that a "point in space" is equivalent to a given material reference-frame and three numbers or *coordinates*. If, for any reason, we prefer to use a new material reference-frame the coordinates or measurements will change and, if we know the relative positions of the two material reference-frames, there is a definite relation between the two sets of three coordinates which is termed a transformation of coordinates. But which particular material reference-frame shall we use? The first choice would, we think, be that attached to the earth. But, even yet, we are in doubt as there are numberless Cartesian frameworks attached to the earth (as to any material body) and it is here that our idea (b) begins to function. We say it must be immaterial which of these Cartesian frames we use. In each frame a *vector* has three components and when we change from one frame to another the components change in such a way that if two vectors have their three components equal in one framework they will be equal in any other attached to the *same* material system. So our idea (b), which says that our physical equations must be vector equations, is equivalent to saying that the choice of the framework attached to any given material body can have no effect on the mode of expression of a natural law.

Shall we carry over our idea (b) to answer the next question: "To which material body shall we attach our framework?" To this question Newton gave one answer and Einstein another. We shall first consider Newton's position and then we may hope to see clearly where the new theory diverges from the *classical* or *Newtonian* mechanics. Newton's answer was that there is a particular material frame with reference to which the laws of mechanics have a remarkably simple form commonly known as "Newton's laws of motion" and so it is preferable to use this framework which is called an *absolute* frame.

What is the essential peculiarity of an absolute frame? Newton was essentially an empiricist of Bacon's school and he observed the following facts. Let us suppose we have a framework of reference attached to the *earth*. Then a small particle of matter under the gravitational influence of surrounding bodies, including the earth, takes on a certain acceleration A_1. Now suppose the surrounding bodies removed (since we cannot remove the earth we shall have to view the experiment as an abstraction), and another set introduced; the particle, being again at its original position, will begin to move with an acceleration A_2. If both sets of surrounding bodies are present simultaneously the particle begins to move with an acceleration which is *approximately but not quite* the sum of A_1 and A_2. Newton postulated that there is a certain absolute reference frame in which the approximation would be an equality; and so the acceleration, relative to the material frame, furnishes a convenient measures of the effect of the surrounding bodies—which effect we call their *gravitational force.* Notice

that if the effect of the surrounding bodies is small the acceleration is small and so we obtain as a limiting case, *Newton's law of inertia* which says that a body subject to no forces has no acceleration; a law which, as Poincaré justly observed, can never be subjected to experimental justification. The natural questions then arise: which is the absolute and privileged reference-frame and how must the simple laws be modified when we use a frame more convenient for us—one attached to the earth let us say? The absolute frame is one attached to the fixed stars; and to the absolute or "real" force defined as above, we must add certain terms, usually called centrifugal forces. These are referred to as *fictitious* forces because, as it is explained, they are due to the motion of the reference-frame with respect to the absolute frame and in no way depend on the distribution of the surrounding bodies. Gravitational force and centrifugal forces have in common the remarkable property that they depend in no way on the material of the attracted body nor on its chemical state; they act on all matter and are in this way different from other forces met with in nature, such as magnetic or electric forces. Further Newton found that he could predict the facts of observation accurately on the hypothesis that two small particles of matter attracted each other, in the direction of the line joining them, with a force varying inversely as the square of the distance between them. This law is an "action at a distance" law and so is opposed to the idea (a).

We have tacitly supposed that the space in which we make our measurements is that made familiar to us by the study of Euclid's elements. The characteristic property of this space is that stated by the theorem of Pythagoras that the distance between two points is found by extracting the square root of the sum of the squares of the differences of the Cartesian coordinates of the two points. Mathematicians have long recognized the possibility of other types of space and Einstein has followed their lead. He *abandons the empiricist method* and when asked what he means by a point in space replies that to him a point in space is equivalent to four numbers *how obtained it is unnecessary to know a priori;* in certain special cases they may be the three Cartesian coordinates of the experimenter (measured with reference to a definite material framework) together with the time. Accordingly he says his *space is of four dimensions.* Between any two "points" we may insert a sequence of sets of four numbers, varying continuously from the first set to the second, thus forming what we call a curve joining the two points. Now we define the "length" of this curve in a manner which involves all the points on it and stipulate that this length has a physical reality, *i.e.*, according to our idea (b) its value is independent of the particular choice of coordinates we make in describing the space. Among all the joining curves there will be one with the property of having the smallest length; this is called a *geodesic* and corresponds to the straight line in Euclidean space. We must now, for lack of an *a priori* description of the actual significance of our coordinates, extend the idea of vector so that we may speak of the components of a vector no matter what our coordinates may actually signify. In this way are introduced what are known as *tensors;* if two tensors are equal, *i.e.*, have all their components equal, in any one set of coordinates they are equal in any other and the fundamental demand of the new physics is that *all physical equations which are not merely the expression of equality of magnitudes must state the equality of tensors.* In this way no one system of coordinates is privileged above any other and the laws of physics are expressed in a form independent of the actual coordinates chosen; they are written, as we may say, in an absolute form.

THE GRAVITATIONAL HYPOTHESIS

Einstein flatly denies Newton's hypothesis that there is an absolute system (and, indeed, many others before him had found it difficult to admit that so insignificant a part of the universe as our fixed star system should have such a privileged position as that accorded to it in the Newtonian Mechanics). In any system, he says, we have no reason to distinguish between the so-called *real* gravitational force and the so-called *fictitious* centrifugal forces—if we wish so to express it gravitational force is fictitious force.[1] A particle moving in the neighborhood of material bodies moves according to a law of inertia—a physical law expressible, therefore, in a manner quite independent of the choice of coordinates. The law of inertia is *that a particle left to itself moves along the geodesics or shortest lines in the space.* If the particle is remote from other bodies the space has the Euclidean character and we have Newton's law of inertia; otherwise the particle is in a space of a non-Euclidean character (the space being always the four-dimensional space) and the path of the particle is along a geodesic in that space. Einstein, in order to make the theory more concrete, makes a certain stipulation as to the nature of the gravitational space which stipulation is expressed, as are all physical laws, by means of a tenso equation—and this is sometimes called his law of gravitation.

Perhaps it will be well, in exemplification, to explain why light rays, which pass close to the sun, should be bent according to the new theory. It is *assumed* that light rays travel along certain geodesics known as minimal geodesics. The sun has an intense gravitational field near it—or, as we now say, the departure of the four-dimensional space from the Euclidean is very marked for points near the sun—but for points so remote as the earth this departure is so small as to be negligible. Hence the form of the geodesics near the sun is different from that near the earth. *If the space surrounding the sun were Euclidean the actual paths of the light rays* would appear different from geodesics or straight-lines. Hence Einstein speaks of the curvature of the light rays due to the gravitational field of the sun; but we must not be misled by a phrase. Light always travels along geodesics (or straight lines—the only definition we have of a *straight-line* is that it is a geodesic); but, owing to the "distortion" of the space they traverse, due to the sun, these geodesics reach us with a direction different from that they would have if they did not pass through the markedly non-Euclidean space near the sun.

The consideration of the fundamental four-dimensional space as being non-Euclidean where matter is present gives a possibility of an answer to the world old question: Is space finite or infinite?: Is time eternal or finite? The fascinating possibility arises that the space may be like the two-dimensional surface of a sphere which to a limited experience seems infinite in extent and flat or Euclidean in character. A new Columbus now asks us to consider other possibilities in which we should have a finite universe—finite not only as to space measurement but as to time (for the space may be such that all of the four coordinates of its points are bounded in magnitude). However, although Einstein speaks of the possibility of a finite universe, we do not, personally, think his argument convincing. Points on a sphere may be located by the Cartesian coordinates of their stereographic projections on the equatorial plane and these coordinates, which might well be those actually measured, are not bounded.

THE SPECIAL RELATIVITY THEORY

In our account of the Einstein theory we have not followed its historical order of development for two reasons. Firstly, the earlier Special Relativity Theory properly belongs to a school of thought diametrically opposed to that furnishing the "General Theory of Relativity" and, secondly, the latter cannot be obtained from the former by the process of generalization as commonly understood. Einstein, when proposing the earlier theory, adopted the position of the empiricist so that to him the phrase, *a point in space*, had no meaning without a material framework of reference in which to measure space

[1]Not all gravitational fields may be transformed away by a proper choice of coördinates. If this were so, the space, whose nature is independent of any choice of coördinates, would always be Euclidean.

distances. When he came to investigate what is meant by time and when he asked the question "what is meant by the statement that two remote events are simultaneous?" it became evident that some mode of communication between the two places is necessary; the mode adopted was that by means of light-signals. The fundamental hypothesis was then made that the velocity of such signals is independent of the velocity of their source (some hypothesis is necessary if we wish to compare the time associated with events, when one material reference-system is used, and the corresponding time when another in motion relative to the first is adopted). It develops that time and space measurements are inextricably interwoven; there is no such thing as *the* length of a body or *the* duration of an event but rather these are *relative* to the reference-system.[2] Minkowski introduced the idea of the space of events—of four dimensions—but this space was supposed Euclidean like the three-dimensional space of his predecessors. To Einstein belongs the credit of taking from this representation a purely formal mathematical character and of insisting that the "real" space—whose distances have a physical significance—is the four-dimensional space. But we cannot insist too strongly on the fact that in the gravitational space of the general theory there is no postulate of the constancy of velocity of a light signal and accordingly no method of assigning a time to events corresponding to that adopted in the special theory. In this latter theory attention was confined to material systems moving with uniform velocity with respect to each other and it developed that the velocity of light was the ultimate velocity faster than which no system could move—a result surprising and *a priori* rather repugnant. It is merely a consequence of our mode of comparing times of events; if some other method—thought transference, let us say—were possible the velocity of this would be the "limiting velocity."

In conclusion we should remark that the postulated equivalence of "gravitational" and "centrifugal" forces demands that anything possessed of inertia will be acted upon by a gravitational field and this leads to a possible identification of matter and *energy*. Further our guiding idea (a) will prompt us to say, following the example of Faraday in his electrical researches, that the geodestics of a gravitational space have a physical existence as distinct from a mere mathematical one. The four-dimensional space we may call the *ether*, and so restore this bearer of physical forces[3] to the position it lost when, as a three-dimensional idea in the Special Relativity Theory, it had to bear an identical relation to a multitude of relatively moving material systems. The reason for our seemingly paradoxical title for an essay on Relativity will be clear when it is remembered that in the new theory we consider those space-time properties which are *absolute* or devoid of reference to any particular material reference-frame. Nevertheless, although the general characteristics of the theory are thus described, without reference to experiment, when the theory is to be tested it is necessary to state what the four coordinates discussed actually are—how they are determined by measurement. It is our opinion that much remains to be done to place this portion of the subject on a satisfactory basis. For example, in the derivation of the nature of the gravitational space, surrounding a single attracting body, most of the accounts use Cartesian coordinates as *if the space were Euclidean* and step from these to polar coordinates by the formulæ familiar in Euclidean geometry. (Newton's law of gravitation is found to be a first approximation and a higher order of approximation explains the famous irregularity in the motion of the planet Mercury). But these details are, perhaps, like matters of elegance, if we shall be allowed to give Einstein's quotation from Boltzmann, to be left to the "tailor and the cobbler."

[2]Thus when it is said that a body contracts or that a clock runs slow when it is put in motion no actual physical change is implied. The judgment of different observers—one at rest with respect to the body and one not—are different.

[3]Necessary to avoid an "action at a distance" theory.

BUILDING A WALL AROUND THE NORTH POLE

IN a recent lecture delivered at the well-known Norwegian city, Bergen, Prof. M. Bjerknes made the startling proposal that a wall should be built around the North Pole in the effort to protect mankind from the effects of the bitter cold waves and icy storms, which sweep southward from that region. This proposition, of course, must not be taken too literally, but rather as an effective image of speech. As reported in *Prometheus* (Berlin), No. 42, 1920, and reproduced in the *Naturwissenschaftliche Umschau*, the Supplement of the *Chemiker Zeitung* (Berlin) for September, 1920, Professor Bjerknes is of opinion that it would be of the greatest advantage for the weather service of all the countries in the Northern Hemisphere to establish a ring of meteorological stations around the North Pole, for the purpose of giving warning of probable polar storms. He declares that the majority of the accidents at sea which have taken place during recent years can be ascribed to the lack of information in advance concerning those dangerous storms occasioned by cold currents of the arctic atmosphere. In such cases forewarned would be forearmed, since it is believed that the information received from such meteorological stations would readily enable meteorologists to foretell the weather for a full week in advance, thus making it possible to advise captains of ships running between Europe and America as to the best ocean paths to follow in order to be sure of good weather throughout the entire journey. It is estimated by the author of this suggestion that from 300 to 500 stations in a circuit about the North Pole would be required to furnish a sufficient amount of data, and the immediate expenditure for establishing these is estimated at 10,000,000 kr. The plan, undoubtedly, has much in its favor and the proposed expenditure seems comparatively small in view of the benefits that would undoubtedly result from it.

THE ORIGIN OF DUNES AND THE BALANCE OF NATURE

A GERMAN geologist, Mr. W. Behrmann, recently published in the Journal of the Berlin Geological Society, *Zeitschrift d. Gesellschaft f. Erdkunde* (Berlin) No. 3-4, 1919, a theory of the origin of dunes which is not only interesting in itself, but which suggests far-reaching conclusions as to the equilibrium of natural forces, and the methods by which this balance is from time to time disturbed. He believes that the dunes may well have originated in the track left by an animal. Such a track, slight as the impression made in the sand may be, occasions a slight deviation of the wind. Thus there is produced a scarcely perceptible sand wave which begins to increase in size until it results in a huge dune. After a longer or shorter period the growth of the dune comes to an end, just as a sand bar formed by a river is eventually destroyed by the river itself. Behrmann states his theory that there is a constant effort in the nature which surrounds us to produce an equilibrium of forces. But this equilibrium is disturbed by any sort of action, such, for example, as the track made by the animal in the sand; in this instance, for example, the velocity of the wind is lessened at certain places by the aforesaid track. From this first disturbance there follows a second which is stronger in action and reaction. The growth of the dune continues until its very increase in size finally reaches a point where it acts as an opposing force. If the dune rises above the stratum of air where wind blows and sand is borne then the sand bank can no longer maintain itself against the increased force of the waters it dams up, so that a state of equilibrium is produced. The formula thus stated in readily comprehensible terms applies not only to the sand dune, but to the increase of strength in various other natural forces, which very augmentation leads finally to a condition of equilibrium. It will be seen that this principle is capable of wide extension throughout nature.—Translated from an abstract in the *Naturwissenschaftliche Umschau* of the *Chemiker Zeitung* for June, 1920.

FIG. 1. A HUNTER FROM THE CUEVA DEL MAS D'EN JOSEP—½ NATURAL SIZE

FIG. 2. ARCHER FROM THE ROCK FRIEZE OF ALPERA—½ NATURAL SIZE

FIG. 3. RUNNERS FROM THE CUEVA DE LOS CABALLOS—⅓ NATURAL SIZE

Artists of the Glacial Period*

Prehistoric Rock Paintings Recently Discovered in Eastern Spain

By Prof. Hugo Obermair

THE cave paintings which have been discovered during the last two decades in no inconsiderable quantities in western Europe and which indisputably date from the glacial period, undoubtedly belong to the most surprising of all the discoveries made in the realm of the history of primeval days. The reader is probably familiar with the remarkable works of art found in Comabrelles, Font-de-Gaume, Laussel, and Marsoulas in southern France, to which must be added those in northern Spain (especially in the Provinces of Santander, Asturias), including the celebrated caves of Altamira, Castillo, Pasiega and Pindal. From all these caverns there have been obtained a number of paintings, or carvings on rock, most notable among which are the large and extremely realistic pictures of animals, including the mammoth, the wild horse, the bison, the reindeer, the mountain goat, the cave lion, etc.; to these must be added some singular half-animal caricatures and certain still unexplained "symbolic" characters. Among the above pictures, which are painted by means of charcoal and red and yellow ocher, scenic groupings are never found, and naturalistic looking representations of human beings are also entirely lacking.

It is now no longer doubted among experts in the matter that these productions of art, which are in many cases of very admirable quality, were the creation of the diluvial period, and, likewise, of the time of the disappearance of the glacial period (Vide H. Obermaier, *der Mensch der Vorzeit*) (Man in Prehistoric Times, Berlin, 1912, Chapter V, pp. 223-258). It is further evident that this art originally fell within the domain of the religious ideas connected with the chase and with the world of spirits, on which account we are apt to find in each of the great zones only a few painted caves, which were probably held to be "sacred" and served as altars of culture.

In contrast to these works of art found in the Aquitania-Cantabria zone, which have been quite well known for a number of years, is another art zone confined exclusively to the eastern half of Spain, extending from the provinces of Lérida and Teruel to the provinces of Jaén and Almeria. This *Levantine art*, as it may be called, has been revealed only very recently, in large part during the war, during which period I had the privilege of lending some considerable assistance in the affair.

Only a few large caverns are found in eastern Spain, and these are buried as in the northern part of the peninsula in the deep recesses of the mountains; on the other hand there is a plentiful supply of shallow, rocky cavities or niches over which a protecting roof of rock frequently projects. As a typical example I may mention here the *Cueva de los Caballos* or *Cave of Horses* which is 9 meters long, 3 meters deep, and about the same height on an average. This cave is difficult of access, being situated in the upper third of the deeply cleft and precipitous slope (about 100 meters in height) of the Valltorta Gorge, which lies not far from Albocàcer in the province of Castellon. In this same locality are found also the *Cueva del Civil* and the *Cueva Salvadora*, which are destined to rouse an international interest (H. Obermaier v. P Wermert *Las Pinturas Rupestres* (Rock Paintings) *del Barranco de Valltoria*, Castellon, Madrid, 1919). The illustrations which accompany this article are reproduced from the pages of this monograph.

Among these Levantine images carvings are found but seldom, while paintings, executed usually with light or dark red pigments, are much more plentiful. Since these are exposed to the more or less direct rays of the hot sun of this climate, they are usually a good deal faded or else obscured by an incrustation of dust. It is only necessary, however, to moisten them carefully with a sponge to see them in many cases revived in all their freshness. This application of the sponge does not injure the pictures, since the pigments which were probably rubbed up originally with grease, have formed in the course of centuries a chemical union with the surface of the rock, so that they may be said to have actually become "fossilized." Doubtless, of course, time and the hand of man have either wholly or partially destroyed many others.

The figures observed in this zone of eastern Spain are quite as realistic as those in the northern zone of Cantabria, but are in general much smaller. Many pictures of animals are found including deer, mountain goats, wild cattle, wild horses, and wild boars, as occasionally also the wild ass, the elks and the chamois.

The peculiar interest of this group of pictures, however, resides in the fact that it contains *numerous representations*

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of the human form done in a most realistic manner, in contrast to the northern zone where, as we have said, such pictures are entirely lacking and which were evidently carefully abstained from.

These "portraits" of human beings are usually full of life and motion. Female figures very seldom appear among them, and when they are seen they are clad in long bell-shaped skirts; the male figures are always naked, but usually carry weapons and wear certain ornaments as shown in Fig. 1. Among these are seen very wonderful caps and "crowns" as well as armlets and knee bands, while attached to the shoulders or hips are fluttering ribbon-like decorative strips of material. Very conspicuous in these pictures are the bows and arrows with which hunters or warriors are armed; there are usually a number of extra arrows in evidence by way of a reserve supply, and now and then a regular quiver is provided for these as indicated in Fig. 2. The figures are portrayed in the greatest variety of attitudes and often with a daring which is truly amazing and rather takes one aback.

While in some of the pictures great regard is paid to correct proportions of the human body and to the realistic representation of the more important details, in others this fidelity to nature is more or less sacrificed in favor of picturesqueness of movement, or in order to give a special emphasis to certain physical characteristics. Thus we often see

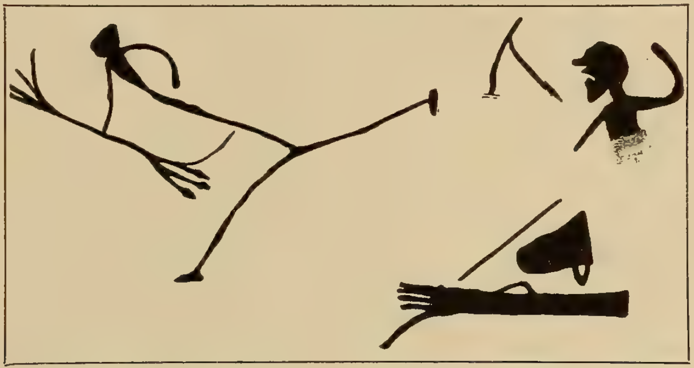


FIG. 4. HUNTER DONE IN RED, FROM THE CULVA DE LOS CABALLOS—ABOUT ⅓ NATURAL SIZE

FIGS. 5 AND 6. FROM THE CUEVA SATTADORA. *ABOVE*, FIGURE IN RED; *BELOW*, A QUIVER AND COOKING UTENSIL

types which are actually "caricatures," with an excessive length of the body, with an extremely broad chest, or with the most daring narrowing of the hips, as well as on the other hand figures with excessively fat legs as shown in Fig. 3. In the same way there are "hunters" whose figures are reduced almost to merely linear dimensions and yet almost seem all the more to fairly live and breathe as in Fig. 4.

Faithfulness of portraiture is not sought for and the pictures are, therefore, to be regarded as "non-individual," since there is always found an omission of details of the head. In those few exceptions where details of the face are reproduced they are not conclusive, so that it is not possible to form from them any definite idea as to the peculiarities of the race which produced them.

These pictures of human beings consist partly of single figures and partly of groups of men or of men and animals, and in such cases they form true pictorial compositions. Thus we possess vivid scenes of deer hunting from the *Cueva de los Caballos* and the *Cueva del Mas d'en Josep* (the Barnyard of Joseph), both situated in the Valltortas Gorge, a superb wild boar baiting from the *Cueva del Charco del Agua Amarga* (the Cave of the Pool of Bitter Water) in the province of Teruel, camp scenes from the last mentioned rocky grotto as well as from Alpera in the province of Albacete; a group of dancing women from Cogul in the province of Lérida; an original trail finder from Morella la Vella in the province of Castellon and many others.

Now and then one comes across really charming "genre" pictures of which we reproduce the example shown in Fig. 6. This represents a quiver which is furnished with a handle and from which extend four arrows and a bow, together with a basket possibly made of skins, and a slender rod or staff.

H. Breuil, P. Wernert, and other experts upon rock pictures, as well as myself are convinced that this naturalistic Levantine art of Spain, is a contemporary equivalent of the Cantabrian zone of art mentioned in the beginning of this article, and that it belongs, like the latter, to the end of the glacial period. Evidence of this is to be found in the many and indisputable similarities of style and technique between the animal pictures in both zones, among which are found certain ones which in the east, as well as in the west, are solely diluvial, such as the wild ass and the elk. A minute study of the character of the weapons and of the ornaments of these naked figures of huntsmen leads to the same conclusion, as does, also, the fact that the naturalistic rock art of the Iberian Peninsula had in general disappeared at about the beginning of the present geological era (*i.e.*, at about 12 to 15 thousand years B.C.), "giving way to an art" purely diagrammatic and geometrical in character (*Vide* my work *El Hombre Fosil* [Fossil Man], Madrid, 1916, Chapter X.).

As respects the psychological background of this art of eastern Spain we are of the belief that it is mainly connected with ideas of magic, either in the form of protective magic or else of enemy magic or the magic of the chase. It seems probable that it was because of such a connection of ideas that the artist carefully refrained from making individual likenesses or "portraits" from the fear that these might be employed as means of evil by crafty practicers of "black magic."

However this may be, these most recent discoveries give us, at any rate, valuable information as to our remotest ancestors, information concerning their forms of art and their personal adornments, their habits and their occupations, such as only a few years ago the boldest fancy dared not hope to obtain.

WHAT KIND OF GOODS DYES BEST?

The following information which is of importance to cleaners and dyers as well as to those who may carry on such operations in their own homes is taken from the January issue of *Dye Stuffs:*

"Goods containing yellow, such as brown, tan or orange, should be dyed dark brown, dark green, plum or black. They do not dye good blue.

"Blue, gray, and taupe should be dyed dark blue, red, burgundy, plum, green or black. Faded gray or taupe does not cover well in darker shade of same color and should be made one of the above colors, or a dark brown. Blue will not dye brown, nor brown blue.

"Corduroys do not, as a rule, make nice black, but do make nice colors. Checked garments should never be dyed black, but can be made dark green, green or brown.

"Hard woven goods that are faded do not cover well in any color but black. Soft materials, such as velours, when not too badly faded, can be covered in one of the darker shades.

"Made over garments that have contained plaits, if faded, must always be dyed black. White serges that are sunburned can only be dyed black.

"Buttons, buckles and fancy trimmings should be removed. It is also advisable to let out hems of sleeves and skirts to provide for shrinkage, which sometimes occurs.

"No dyer can keep goods from shrinking, if they are inclined to do so, no matter how careful he is in dyeing.

"Following are a few points concerning the plaiting of skirts:

"Plaiting takes up something like 2-3; for instance, 3 yards of goods plaited will be one yard wide.

"The average skirt has from 3 to 3½ yards.

"Goods to be plaited should be put in 'sheet-like form' so it can be placed in the plaiter, hemmed or faced at bottom, sewed together except at one seam, say at vent or placket.

"Plaited goods can be cleaned any number of times without replaiting."

The Bridge as a Test of Civilization*

Varying Degrees of Ingenuity and of Technical Ability Shown by Savage Tribes

By Professor-Doctor K. Waule

ONE of the truest measures of the civilization of any race is to be found in its means of traffic, and this holds true both of highly civilized nations and of savage tribes and upon water as well as upon land. But while the most primitive and backward of native tribes manages to cover considerable distances on solid ground in the presence of the more difficult obstacles presented by streams and seas many groups of mankind have remained entirely helpless, being not sufficiently ingenious to discover or invent the simplest means for crossing stretches of water. Among such races are some few African tribes as well as most Australian ones, besides certain groups of South American Indians dwelling in the eastern Andes; these peoples have been obliged to compensate in a measure for the lack of bridges and boats by an increased skill in the art of swimming.

Both from the technical and from the ethnographic view

FIG. 1. BRIDGE IN THE VILLAGE OF TIMBUNKE OVER THE KAISERIN AUGUSTA RIVER, NEW GUINEA. AFTER RECHE

point it is not without interest to study the primitive origin of bridge building, since this evidently presents a problem of more difficulty than that of making boats. The first bridges were undoubtedly the fallen trees lying across streams and the heavy vines or *lianes* crossing them. Such original bridges were discovered without difficulty. Man had only to follow the example of the animals in flight which chose such means of escape. In the case of the swinging vine, however, the problem is twofold, since the savage was called on to decide whether to cross it by means of his feet or by means of his hands. Here we have the problem of the stable equilibrium which any hanging body possesses when suspended from a rope, and the human observers doubtless took lessons from such animals as sloths and apes. The next step in advance concerned the problem of unstable equilibrium, one far more difficult to learn, and one with regard to which man probably found no natural teacher; it appears probable that under extraordinarily favorable circumstances and quite by chance a second vine happened to run above the first one in a slant line so that the first man who trod upon the dizzy road of the lower vine had a natural railing by which to support himself. The idea of such a natural railing or balustrade is a necessary concept which is proved by the fact that today wherever swinging bridges of vines are employed such a support is present. On the other hand, the implied difficulty of the invention and development indicate that these swinging bridges must have been of later appearance in technological history than the footpath across the fallen tree. Such swinging bridges are of rarer occurrence likewise and are practically confined to the dense primeval forest. An exception to this is found at the present day in the hanging bridges composed of thongs of skin known as *tarabites* and found among the Cordilleras of South America, for whose invention the same basic principle doubtless stood as sponsor.

The ancient bridge made of the trunk of a tree continued to develop in the form of the wooden bridge almost to the present time, but the first iron bridges were erected at Colebrookdale from 1773 to 1779, while the first German iron bridge was not built till 1794. Technologically speaking, the wooden bridge falls into three classes: Bridges of solid beams and girders, trestle bridges and suspension bridges. The latter rest exclusively upon vertical supports or A-frames. In the trestle bridges the footpath or carriage road is supported not only by vertical supports but by a system of inclined poles which interact upon each other. In the suspension bridge, finally, the roadway has sloping approaches and girders of very similar arrangement to the trestle bridge. In addition we may probably regard as the most advanced of the primitive forms the arched beam bridge of which we are able to present a very remarkable example.

The original form of the girder bridge is, as we have said, the fallen tree lying across the stream. When such a trunk happened to be smooth and unencumbered by branches it was ready to use at once; when this was not the case the primeval savage readily perceived that he must somehow get rid of the troublesome branches and twigs. The next step in develop-

FIG. 2. VERY ANCIENT BRIDGE OVER THE ADULLA IN BRITISH NEW GUINEA. AFTER PHOTOGRAPH BY HAMANN

ment from the use of a tree felled by chance, as by storms or floods, and the felling purposely of a suitable tree in any desired direction was undoubtedly more difficult. We of modern times can hardly understand, indeed, how great was the necessity for skilful judgment, since we are provided for accomplishing the same purpose with long ropes and cables to pull the tree in any given direction as well as with sharp axes and saws, to say nothing of our long experience.

But such a bridge formed of a single beam or trunk demanded the keenest judgment to decide whether the length was too great for the supporting capacity or whether the diameter was insufficient, or whether to begin with, the stem of the tree was long enough to reach to the other side. In the former case the beam needed to be strengthened by sup-

*Translated for the *Scientific American Monthly* from *Kosmos* (Stuttgart) for June, 1920.

ports or yokes, whereas in the latter case the bridge required lengthening by the addition of one or more other beams, which in their turn had to be strengthened.

In this respect most surprising discoveries have been made by the members of the numerous expeditions which during the last few years preceding the war explored the Kaiserin Augusta River or Sepik in the interior of the great island of New Guinea. Little was known of the inhabitants of this interior region, since previous expeditions had confined themselves mainly to the coastal zone. All the more amazed, therefore, were the explorers to find along the winding river courses populous villages containing buildings with which the houses of our own German villages are unable to compete, either in architecture or in purity of style. Of a special stateliness are the ceremonial buildings with their gable roofs sweeping boldly to a height of 15 meters or more, and their length of as much as 30 meters. These structures, too, are gaily decked with color and are of great ethnographic interest—their inventory includes hanging brackets or hooks carved into all sorts of fantastic forms, from which depend various tools and household utensils. The great slit-formed signal drums and the bass drums shaped like an hour glass, together with marvelous representations of the animal kingdom in brightly tinted wooden structures, the richly carved white shields, etc., are full of interest.

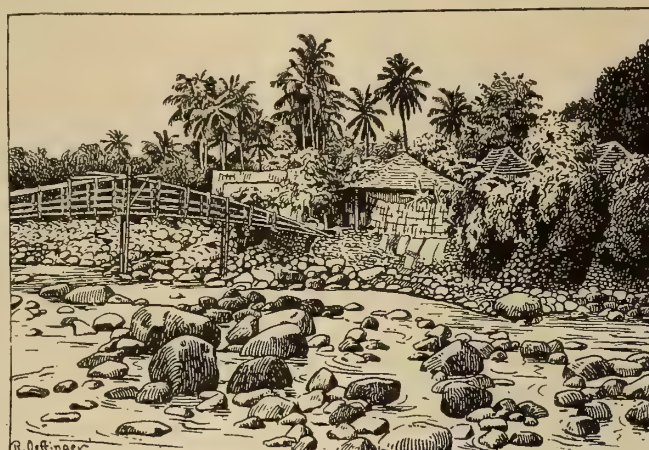


FIG. 3. BRIDGE OF BAMBOO AT BUITENZORG, JAVA

Here, however, we will give only an illustration of the bridge in the large village of Timbunke, in interior Sepik. The architecture of this bridge appears to us quite simple, but when we consider the low degree of cultural development among the Sepik race it represents a very able piece of technical work. This is obviously quite aside from the degree of civilization of the constructors, since the Sepik like so many rivers of lowland regions has raised its bed above its surroundings so as to overflow the plain on both sides to a considerable height. When such an overflow occurs it takes place in an incredibly short time and the bridge builders were obliged to take this awkward circumstance into consideration; that they have done so is plainly seen in the picture from the height of the yokes, as well as from their construction with respect to the stream. The footpath—there is no question of a driveway in New Guinea—does not give the correct idea. However, we could reconstruct this for ourselves by imagining the orderly laying in place of the beams piled up in front of the bridge. As Professor Ruche, the official artist of the Sepik expedition, suggests, it is probable that the natives, taking alarm at the many strangers who had penetrated among them had removed the upper structure in part, so as to make a passage from one shore to the other considerably more difficult. The remainder of the bridge does not consist, as would appear from the picture, of a single beam, but of two beams lying side by side and with free-swinging ends. The waters thus bridged form a communicating canal between the River Sepik and the great back water swamp in the interior regions of Timbunke.

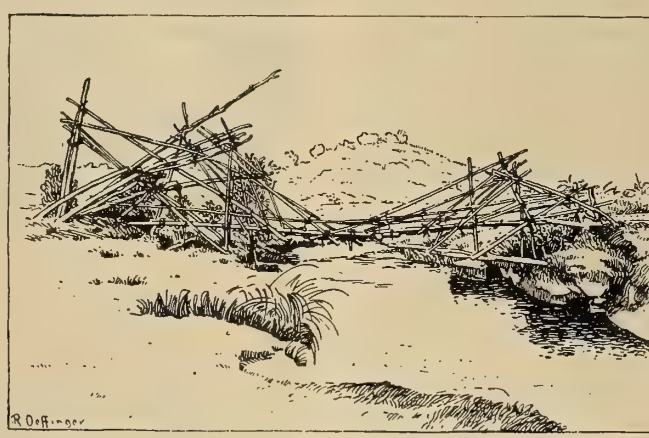


FIG. 4. BAMBOO BRIDGE AT RANTEPAO, CELEBES

Fig. 2 shows us a bridge in the eastern part of the same island in British New Guinea, in the country of the Mafulu. Judging from the appearance of these people and from their settlements, they must be an extremely primitive race. At first glance the structure made by them across the roaring waters of the Adualla River appears to be merely a sort of improved footpath or beam, but closer examination shows that we have here an instance of a true truss frame in which the main beams of the bridge are placed obliquely to each other from the banks, and at the intersections of the interlacing members are fastened to each other in crotches. For further strengthening the structure railings with uprights firmly attached to them, are employed, besides the longer poles which project from the railings to a rock in the river bed. As in all structures erected by primitive races, neither nails nor screws are employed, but the separate parts are all bound together by cords and ropes made of plant fibers. Even among the Malays, this method of binding is employed.

Fig. 3 takes us among the aforesaid Malays. It represents a foot bridge in Java in a comparatively civilized neighborhood. This explains the beautiful form of the entire structure, which otherwise is pure Malay. We have here a truss bridge with a suspended floor since the footpath is suspended in loops of rattan which ride at equal distances upon the beams which cross each other at the middle of the bridge. Upon the left side of the picture they run pretty much parallel to each other, which scarcely corresponds to the requirements of scientific construction; upon the other side, on the contrary, they appear to be parabolic like the footbridge itself and are, therefore, perfectly adapted to the required purpose. The pole supports which are anchored in the river bed are, undoubtedly, of more protection against wind and water pressure than of assistance in supporting the bridge itself. All the connections in this bridge of the different parts with each other are made, as is usual with the Malays, by binding with strips of rattan, etc.

A far bolder piece of construction is shown in the bridge represented in Fig. 4, located at Rantepao on the island of Celebes. It is believed, indeed, that in this bridge we actually have the forerunner of our modern steel and iron cantilever bridges. Even the indispensable anchorage demanded by such cantilever bridges is present here at one side, although it is lacking on the other. Here it is replaced by a couple of posts which represent to a certain degree the intrinsic character of cantilever construction. This hanging structure presents at first glance a shapeless confusion of bamboo poles. As a matter of fact, indeed, some of these, especially on the left side, are superfluous, but in spite of this the entire structure with its finely swung footbridge gives the impression of a well thought out technical job, not to be despised.

The other primal element of the bridge, *i.e.*, the vine stretched across the river has undergone a double develop-

ment, according to whether the swinging cable has been crossed by a man with his hands or with his feet. In the first form it had been developed into the rope path whose stages of development and area of application we will not here go into, though the subject is fascinating enough. The other basic principle has led in course of its development to the modern suspension bridge with its tremendously manifold forms and its often gigantic dimensions; it forms, indeed, in the technological history of civilized peoples an extremely important division, but it has by no means lost because of that fact its interest as regards the technical arts of the more backward races.


FIG. 5. SUSPENSION BRIDGE OVER THE TJIBADAK, JAVA

The simplest form of the rope bridge is the foot rope with a rope to act as a hand rail or balustrade running obliquely above it. It is hard to believe that anything so remotely ancient still exists. However, in its primitive form, this is the case as is shown by an interesting illustration which appeared in the *Technischen Rundschau* for April 24, 1907, and which is copied by G. Dieterich in his book *The Invention of the Wire Rope Road* (in German) published in Leipsic in 1908. This shows the proximity to each other of an old rope road and a still older rope bridge, both of which span a broad and rushing mountain stream in Kashmir, from one steep bank to the other. The rope road is made of ropes of raw hide about 3 cm. thick. The traveler takes his seat within a couple of rope loops or slings; these are attached to a fork-shaped piece of timber which glides along the rope. This sliding movement is produced by gravity alone, so far as the angle of inclination of the supporting rope permits; over the rest of the way there is a lighter traction rope which hangs in movable rings underneath the supporting rope and which is firmly attached to the sliding piece of timber.


FIG. 6. RATTAN SUSPENSION BRIDGE STEADIED WITH GUY LINES, RANTE MANUK, CELEBES


FIG. 7. BRIDGE WITH STIFFENING HOOPS

The rope bridge operates in a very peculiar manner; it consists of an extremely strong "hand rail" rope twisted together of a number of separate hempen ropes until it forms a cable almost 16 cm. thick, and of a foot rope running obliquely underneath the top rope at a distance of 1½ meters and held in this position by vertical cables. According to our modern feeling the foot rope should be the stronger of the two but references in literature show that this bridge has been in use for an extremely long time, hence the system must have proved itself workable in practice.

The ordinary suspension bridge of modern times has hand rails on both sides; such bridges are found in the interior of western Africa and in New Guinea and elsewhere. This double hand rail not only makes the traveler more secure from a fall but at the same time strengthens the bridge not inconsiderably against the vertical load and the lateral wind pressure. From all accounts the most unpleasant, and at times even dangerous feature of the passage across such a bridge, is the lateral swaying of the foot rope. This statement is supported by the fact that a large percentage of rope bridges are provided with devices intended to prevent this sidewise swinging. In the collection of thousands of photographs in the Leipsic Museum, representing the arts of primitive people, there are dozens and dozens of such pictures of bridges, but among them there are comparatively few which do not exhibit some sort of an attempt at ameliorating the lateral swaying of the foot rope.

The most obvious method of accomplishing this is a lateral attachment of the bridge path and sometimes, also, of the hand rail which is firmly connected with the former to one or more firm and solid points on the bank of the stream above and below the bridge. In these attempts it is naturally not the resultant of the parallelogram of the lines of force which is employed, but only one component thereof, and the more acute the angle of the lateral attachment with the river bank the shorter this component; but these early builders have sought to remedy this disadvantage by a multiplicity of ropes. In the marvelously swung rope bridge shown in Fig. 5, which crosses the broad Tjibadak in Java, both pairs of bamboo rods on the shore abutments merely serve to strengthen the foot bridge, while the fine cords to the left and the right of these are meant to lessen the unavoidable lateral swing. Fig. 6, on the other hand, shows a rattan bridge at Rante Manuk in Celebes, in which both the strengthening of the bridge and the diminution of the lateral sway are achieved by the numerous *lianas* running obliquely upward from the hand rail to the trees crowning the lofty bank. The otherwise incomprehensible upward arching of the bridge exactly in the middle of the span is clearly explained as being due to the effect of the *lianas* or guy lines.

In Fig. 7 we see a real masterpiece of technical bridge building, which is likewise a rattan bridge at Salo Manio in Celebes. Here the lateral braces have been entirely avoided in favor of a complete system of firm and compact rattan ellipses which are bound piece by piece to each separate strand of the hand rail and of the foot bridge at its intersection with them while above the upper end of the great axis there runs a main cable, which is likewise twisted of a specially

stout rattan *liana*. Further strengthening is secured by the interweaving of the hand rail and the footpath with finer rattan cords, apparently made of split rattan. Probably there is no other structure of this sort so admirably insured against vertical and lateral distortion. One receives a similar impression of a constructive masterpiece upon examining the wooden bridge at Osaka, Japan, shown in Fig. 8. Architecturally speaking it belongs not to the rope bridges but to th girder bridges; ethnologically speaking it forms perhaps the finest and most abstract example of that series of developments which we have observed in Figs. 2-4. In order to comprehend this we must recall that the modern Japanese are composed of very various anthropological elements, including a Mongolian element from the opposite mainland, a dash of Ainu blood, and an infiltration of Malay blood.

The Ainus are those very remarkable extremely hirsute dark-skinned people, who are confined in modern times to the northern portion of Yezo, to Sachalin, and to the majority of the Kurileu Islands, whereas before the arrival of the Japanese they occupied practically all of modern Japan down to the southern portion. The Malay immigration is readily explained by the former mobility of this race, who found little trouble in passing from their home in southeast Asia to Madagascar in the west and to Easter Island in the east, thus traveling over more than 200 meridian degrees, *i.e.*, distributing themselves over more than half the circumference of the earth. This Malay strain is borne witness to not only by the strongly marked Malayan form of the body, but also by the nature of the houses, whose original form, a structure of palings or posts, can be explained only by a southern origin, as also certain features in their bridge construction which likewise find a parallel in East Indian territory.

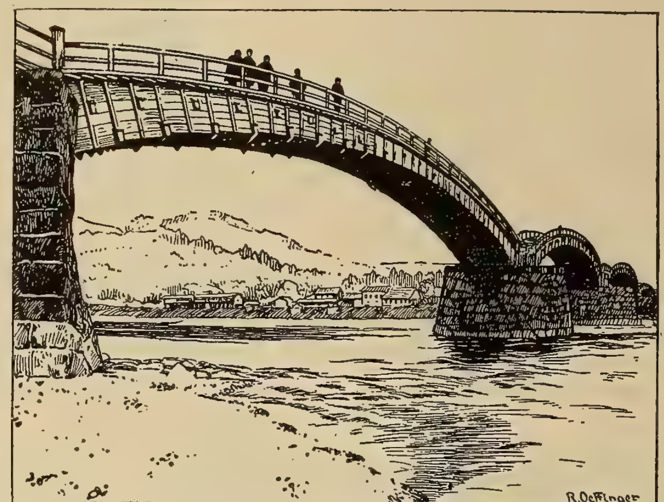


FIG. 8. ARCHED BEAM BRIDGE AT OSAKA, JAPAN

In the case before us the outer form is that of a bridge of arches. Unfortunately, the dark shadows in our picture prevent us from recognizing certain details of the construction, whereas the great original picture in the Leipsic Museum shows an extremely ingenious system of ties and wedges in which presumably nails and screws are as absent as in the original Malay bridges.

While these Japanese and East Indian bridge forms obviously point to a close connection, it is not so easy to answer the question as to the origin of like or similar constructions in the rest of the world. Where did the dwellers in the South American Cordilleras get their *tarabites?* Where did the inhabitants of the Cameroons and the primeval Congo forest come by their bridges of lianes? Where, finally, did our own ancestors obtain sufficient insight into the matter to enable them to pass heavy loads upon ropes or chains across abysses or to send men across rivers and arms of the sea on chain bridges? In his admirably conclusive book, *Zesammenhänge und konvergenz* (Connection and Convergence) published among the reports of the Anthropological Society of Vienna (Vol. XLVIII, 1918 (Vienna), Professor von Luschan answers this question to the effect that there is a historical connection between the development of the human race throughout the entire earth. He points out that the structures recently observed with so much astonishment in such isolated parts of the earth as New Guinea and western Africa have created false impressions; in reality rope bridges and rope roads are found in all parts of the earth so that they may be regarded as probably having a common starting point.

However, possible and even plausible this theory may be, the ethnographer, on the other hand, can easily take a stand upon the opposite standpoint: that individual invention in all those places where no connection with other phenomena of the same kind is provable or probable can be assumed. For example, it may be assumed from the double phenomenon of the rope road and the rope bridge that the repetition of this invention may be due to the simplicity of the basic idea; wherever it has been found a necessity to assume intercommunication it has been found possible to prove the fact.

The conflict between these two ideas among ethnographists has been much in evidence for many decades and the balance still swings between them.

RHINE-MAIN-DANUBE SHIP CANAL

THE linking up of the North Sea with the Mediterranean by a trans-continental waterway was discussed in the court of Charlemagne in 793, and a commencement made, although subsequently abandoned.

A canal connecting the Main with the Danube was actually constructed in 1836 by the Bavarian Government, but only for barges of 126 tons capacity. It has more than 100 locks, and is much too diminutive for modern transport requirements. The Bavarian Parliament voted 5 million marks in 1917 toward the cost of a new Main-Danube canal, which is to connect northern Bavaria with the Danube, and to be suitable throughout for ships 233 feet long by 33 feet wide, with 7 ft. 3 in. draught, viz., 1,200 tons burden. It is, in addition, to accommodate vessels of 1,500 tons burden, viz., 279 feet long by 33 ft. 6 in. beam, from the Danube to Aschaffenburg.

The total length of the proposed canal necessary to join the three rivers, including the length of the canalized river Main and Regnitz, is 451 English miles. The total rise to be negotiated above the sea level is 1,340 feet, requiring 60 locks. It is hoped to transport 12 million tons annually, the average time of transit to be 145 hours. Hydroelectric power to the extent of 168,500 hp. yielding 936 million kw. annually, will also be available. The estimated cost of the canal is 597 million marks.—Abstracted by *The Technical Review* from *Das Technische Blatt*, June 26, 1920.

JUNCTION CANALS FOR THE GERMAN HANSA TOWNS

THE proposal to interconnect the three principal seaports, Hamburg, Bremen and Lübeck, with the four large rivers, Rhine, Ems, Weser, and the Elbe, by means of ship canals is now receiving serious consideration in Germany. The Inland or "Mittelland" Canal from the city of Hanover due west to the rivers Weser and Ems, merging into the Dortmund-Ems Canal and the Rhine, is practically finished, thus converting Hanover into a seaport communicating with the North Sea.

Five new inland waterways are deemed necessary: 1. A direct canal near Bremen to connect the rivers Ems and Elbe. 2. A direct canal from Brunswick to the Elbe, south of Hamburg. 3. A direct canal from Hanover to the Elbe near Hamburg. 4. A canal from the Mittelland canal at Osnabrück via Bremen to Hamburg. 5. A similar canal, also from Osnabrück to Hamburg, with branches to Bremen and Hanover, thus canalizing the river Weser.—Abstracted by *The Technical Review* from *Wirtschaftsdienst*, Sept. 23, 1920.

Psychological Examinations

New and Practical Methods of Measuring Vocational Fitness

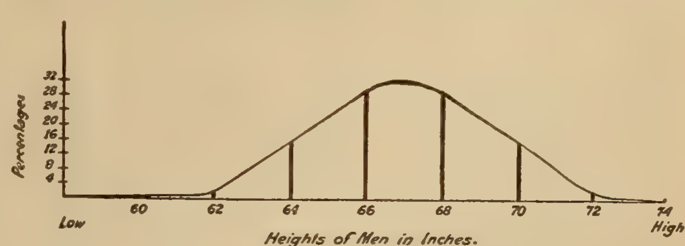
By A. T. Poffenberger
Assistant Professor of Psychology, Columbia University

TESTING THE LABYRINTHINE SENSATIONS BY MEANS OF THE TILTING TABLE

THERE is one fundamental fact underlying all psychological examinations, namely, that people differ in their mental capacities or powers just as they do in their physical characteristics, and that they should be treated according to their capacity. The popular notion, however, seems to be quite the opposite. The Constitution of the United States says that all people are born free and equal, and this is much more often interpreted to mean equal mentally than it is to mean equal physically. The notion of mental equality has been crystallized in our public school system. Only recently and in the most progressive communities have mental differences been officially recognized in school work and some provision made for the instruction of the mentally deficient and those who are unusually bright. The resistance that needs to be overcome in introducing such innovations bears witness to the strength of the equality belief. The many courses of instruction so widely advertised at present, most of them correspondence courses, which promise that any person taking them can become a $10,000 executive, play upon this same belief. The individual who believes that all people are equal in brain power and that only opportunity is needed for rapid advancement will welcome such courses of instruction. The large proportion of such enthusiastic students must be doomed to disappointment, because they are attempting more than their capacity will enable them to accomplish.

The verdict of the psychological laboratory is that men are by nature very different in every respect in which they have been measured; that these native differences are in part responsible for differences in achievement, how much cannot yet be determined; and furthermore that these native capacities determine the limit of achievement possible to every man. Mental capacity or what may be more popularly called "brain power" is distributed among the population very much as the physical characteristics of weight, height, etc., are distributed. That is, it is not possible to divide people into grades or classes according to height, as tall, medium or short; or according to weight as heavy, medium or light. There are all sorts of intermediate heights and weights, so that the tall and heavy gradually shade off into the light and short. The heights of all people may be represented by the following curve, where the various heights in inches are indicated along the horizontal line and the distances above the points on this line indicate the number of people of that particular height.

If some measure of brain power be substituted for inches in this picture the curve would have approximately the same shape. People cannot be divided into the bright and the dull, the honest and the dishonest, the quick and the slow, the



VARIATIONS IN THE HEIGHTS OF MEN[1]

sane and the insane. There are persons who represent all sorts of intermediate stages between these classes. A glance at the curve will show that there are more people of medium height than of any other height, and that the shorter the height the fewer people there are of that height; also the greater the height the fewer are the people who reach that height. The same is true of mental capacity. There are more people of average intelligence than there are of extremely bright or of extremely dull. It has been estimated that there are in the population about one-half of one per cent who are feeble minded. That figure would represent about the pro-

[1]Reproduced from "Industry, Emotion and Unrest," by Edward Thomas, published by Harcourt, Brace and Howe.

TEST FOR MUSCULAR BALANCE OF THE EYES

Trying to make the two pictures blend into one in the prisms in the center of the table

THE COLOR PERIMETER TEST

This instrument is used to measure the field of vision and the color zones of the retina

portion of the people who are extremely bright. It is very convenient, sometimes, to think of people as being divisible into classes or groups or even of all people as being alike. It was necessary for commercial and industrial progress that certain standard forms should be adopted to suit a kind of average person. For example, chairs and tables and steps have been made a standard height, and other articles of daily use are made to fit a kind of hypothetical individual. But these physical standards have not been adopted without sacrifice on the part of the individual. Many short persons are forced to sit at their work in chairs so high that their feet cannot touch the floor, because chairs are made for the average person. But even here progress has been in the direction of giving greater consideration to individual needs. School seats, school desks, typists' chairs, work benches and stools are now made adjustable to suit the varied physical characteristics of the occupants. Much discomfort and injury to health are no doubt prevented in this way. It is impossible to estimate the damage that is being done in trying to fit mental abilities into a standard form, which can fit only the average person. The resulting lack of adjustment is responsible for many of our misfits in life. It has often been said that many a good carpenter has been spoiled in making a poor minister; the reverse is also true and the same statement will apply to every occupation.

The psychological examination, a device for measuring mental capacity, will ultimately be used to find the right work for each person to do, just as the footrule is coming to be used to find the most comfortable and satisfying chair for him to sit in. The psychological measure, however, is infinitely more necessary because the mental adjustments that need to be made are far less obvious than the physical ones, and are much less likely to be provided through common sense. The mental misfits are usually discovered when it is too late for readjustment, and for recovering what is lost.

Since natural differences are thought to be responsible for differences in achievement, the measurement of natural capacity occupies a very important place in psychological measurement. Intelligence is the term most commonly used to indicate this natural capacity and the tests for measuring intelligence have been most fully developed. But there are other natural traits that are not directly dependent upon intelligence but which are just as vital for success. These need to be measured. For lack of a better name we will call these "character traits" to distinguish them from the intelligence traits. They may also be thought of as moral traits as contrasted with the intellectual traits, and comprise honesty, integrity, sociability, kindness, ambition, etc. In addition to these two forms of natural capacity, certain more special capacities must be recognized and measured. Musical, artistic and mathematical ability, inventiveness, motor skill and the like are some of these.

On the basis of these natural capacities people acquire their general education and their special training. Although these attainments are limited by natural capacity, differences of opportunity make any perfect relation between capacity and attainment not to be expected. Hence, measures are needed for these acquired possessions. They are known as educational tests and trade tests. In addition to these forms of psychological examination, namely, the intelligence test, the character test, the educational test and the trade test, what might be called general fitness tests have been constructed and are intended to measure at once all of these traits. Each of these forms of psychological examination will be briefly described.

The best known and the most generally used of the intelligence examinations is the Binet Simon examination in one or other of its modifications. It consists of a measuring scale upon which the units are years of age and any person who is measured on this scale has an intelligence which may be expressed in terms of years. Each year unit on the scale consists of a group of tasks which are to be performed under carefully arranged and standardized circumstances. A few specimens of these units will illustrate their general character:

Second Month.—Occasional strabismus, recognizes human voice, turns head toward sound, pleased with music and with human faces. Laughs at tickling. Clasps with four fingers at 8th week. Uses first consonants.

Third Month.—Cries with joy at sight of father or mother. Eyelids not completely raised when child looks up. Knows sound of watch at 9th week. Listens with attention.

Fourth Month.—Eye movements perfect. Sees objects move toward eye. Joy at seeing itself in mirror. Opposes thumb. Head held up permanently. Sits up with support to back. Begins to imitate.

Fifth Month.—Discriminates strangers. Pleasure in crumpling and tearing paper, pulling hair, or ringing bell. Sleeps ten or eleven hours without food. Sounds consonants l and k. Seizes and carries objects to mouth.

Sixth and Seventh Month.—Raises self to sitting posture. Laughs. Raises and drops arms when pleasure is great. Teeth begin to appear. Astonishment shown by open mouth and eyes. Turns head as sign of refusal.

Eighth and Ninth Month.—Stands on feet with support. Claps hands for joy. Has fear of dogs. Turns over when laid face down. Turns head to light when asked where it is.

Questions understood before child can speak. Voice more modulated,

Thirteenth, Fourteenth, and Fifteenth Months.—Says "Papa and "Mamma." Raises itself by chair. Imitates coughing and swinging of arms. Walks without support. Understands ten words.

Sixteenth, Seventeenth, Eighteenth and Nineteenth Months.—Sleeps ten hours at a time. Associates words with objects and movements. Blows horn, strikes with hand or foot, waters flowers, tries to wash hands, comb and brush hair, and to execute other imitative movements.

Twentieth and Twenty-fourth Months.—Marks with pencil and paper. Executes orders with surprising accuracy.

Twenty-fifth to Thirtieth Months.—Distinguishes colors. Makes sentences of several words. Begins to climb and jump and to ask questions.

Thirtieth to Fortieth Months.—Goes upstairs without help. Clauses formed. Words distinctly spoken. Influence of dialect appears. Much questioning.

Third Year.—Can point to nose, eyes and mouth. Can repeat "It rains. I am hungry." Can repeat the figures 7, 2. Can enumerate objects seen in picture. Knows own name.

Fifth Year.—Knows which is heavier of two weights, 3 and 12 grams, and 5 and 15 grams. Copies a square. Repeats "His name is John. He is a very good boy." Counts four pennies. Can put together two parts of a rectangle cut diagonally.

Seventh Year.—Counts thirteen pennies. Describes pictures. Sees that pictures lack parts, such as eyes, nose, mouth, hands. Copies a diamond. Recognizes red, blue, green, yellow.

Ninth Year.—Makes change 20 cents less 4 cents. Gives real definitions to words in 6th year. Knows date. Knows the months in order. Arranges a series of weights correctly.

Eleventh Year.—Sees absurdities in certain statements. Makes sentence. Gives sixty words in three minutes. Gives words rhyming with day, spring and mill. Puts disarranged sentences together.

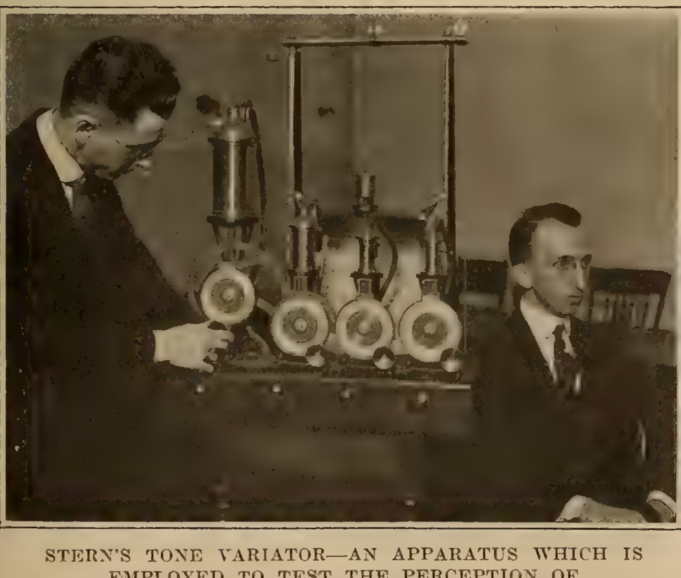
The tasks of each year unit are composed of a collection of things that the average child of that age can do as a result of living in contact with his physical environment and of associating with people but without special instruction. Now if a child of ten years can do all of the tasks up to and including those for year twelve, he is said to have a mental age of twelve; or if he can do all of the tasks only up to and including the age of eight, he is said to have a mental age of eight. This means simply that in the first case the child can do the things that the ordinary child of twelve years can do, and in the second case what the ordinary child of eight can do. If the child's mental age is expressed in terms of its relation to his physical age, we have what is called the intelligence quotient. Thus in the first case above, the child would have an intelligent quotient of 12 divided by 10 or 1.2; and in the second case an intelligent quotient of 8 divided by 10 or .8. When the intelligence quotient is above 1.00 the child is above the average intelligence for his age, and when it is below 1.00, he has less than the average intelligence for his age.

If the test really measures natural intelligence and not the mere product of education, the intelligence quotient, determined for the same child at different ages ought not to change. And this is just what the repetition of the tests seems to indicate. One of the greatest values of the intelligence test is just here, that it will enable the intelligence of the child to be determined very early and his career mapped out accordingly. If a child at the age of six is found to have an intelligence quotient of 1.30, it is a safe prediction that, barring the effects of accident or disease, he will as an adult be considerably above the average in intelligence.

This form of intelligence test, though of great service in measuring children up to the age of 14, has certain drawbacks when used to test adults. When the need for an intelligence examination in the army became apparent, because of the necessity for picking for responsible positions those who would be most competent after their special training, a new form of test was devised which was better adapted for the purpose. This examination can be given simultaneously to hundreds of people and can be scored by untrained persons. The tasks are not arranged in year groups, but in series according to difficulty. Each person does as many of the tasks as the time and his capacity permit. A certain number of points credit is attached to each sort of task, and the intelligence score is given in terms of a letter grade, A, B, C, C, C, D, D, E. This type of examination also measures natural capacity, and although some of the tasks call for specific information, it is such information as an individual of a given degree of intelligence would have acquired from contact with his environment and without special training. For example, some extremely high scores in the army were made by men who had not finished the eighth grade of school. This type of test is of particular interest because it has become the pattern for all of the more recently developed intelligence tests. Specimens of the different tasks follow:

Get the answers to these examples as quickly as you can.
Use the side of this page to figure on if you need to.

1 How many are 5 men and 10 men?.......Answer (15)
2 If you walk 4 miles an hour for 3 hours, how far do you walk? ....Answer (12)



STERN'S TONE VARIATOR—AN APPARATUS WHICH IS EMPLOYED TO TEST THE PERCEPTION OF TONAL DIFFERENCES

TESTING KEENNESS OF HEARING. THE SUBJECT MUST TELL HOW FAR THE WEIGHT FALLS BY LOUDNESS OF IMPACT

This is a test of common sense. Below are sixteen questions. Three answers are given to each question. You are to look at the answers carefully; then make a cross in the square before the best answer to each question, as in the sample:

SAMPLE { Why do we use stoves? Because
☐ they look well
☒ they keep us warm
☐ they are black

Here the second answer is the best one and is marked with a cross. Begin with No. 1 and keep on until time is called.

If the two words of a pair mean the same or nearly the same, draw a line under *same*. If they mean the opposite or nearly the opposite, draw a line under *opposite*. If you cannot be sure, guess. The two samples are already marked as they should be.

SAMPLES { good—bad....................same—opposite
little—small..................same—opposite

The words A EATS COW GRASS in that order are mixed up and don't make a sentence; but they would make a sentence if put in the right order: A COW EATS GRASS, and this statement is true.

Again, the words HORSES FEATHERS HAVE ALL would make a sentence if put in the order: ALL HORSES HAVE FEATHERS, but this statement is false.

Below are twenty-four mixed-up sentences. Some of them are true and some are false. When I say "go," take these sentences one at a time. Think what each **would** say if the words were straightened out, but don't write them yourself. Then, if what it **would** say is true, draw a line under the word "true"; if what it **would** say is false, draw a line under the word "false." If you cannot be sure, guess. The two samples are already marked as they should be. Begin with No. 1 and work right down the page until time is called.

SAMPLES { a eats cow grass.....................true..false
horses feathers have all..............true..false

SAMPLES

2	4	6	8	10	12	*14*	*16*
9	8	7	6	5	4	*3*	*2*
2	2	3	3	4	4	*5*	*5*
1	7	2	7	3	7	*4*	*7*

Look at each row of numbers below, and on the dotted lines write the two numbers that should come next.

SAMPLES { sky—blue :: grass— **table** **green** **warm** **big**
fish—swims :: man— **paper** **time** **walks** **girl**
day—night :: white— **red** **black** **clear** **pure**

In each of the lines below, the first two words are related to each other in some way. What you are to do in each line is to see what the relation is between the first two words, and underline the word in heavy type that is related in the same way to the third word. Begin with No. 1 and mark as many sets as you can before time is called.

Notice the sample sentences:

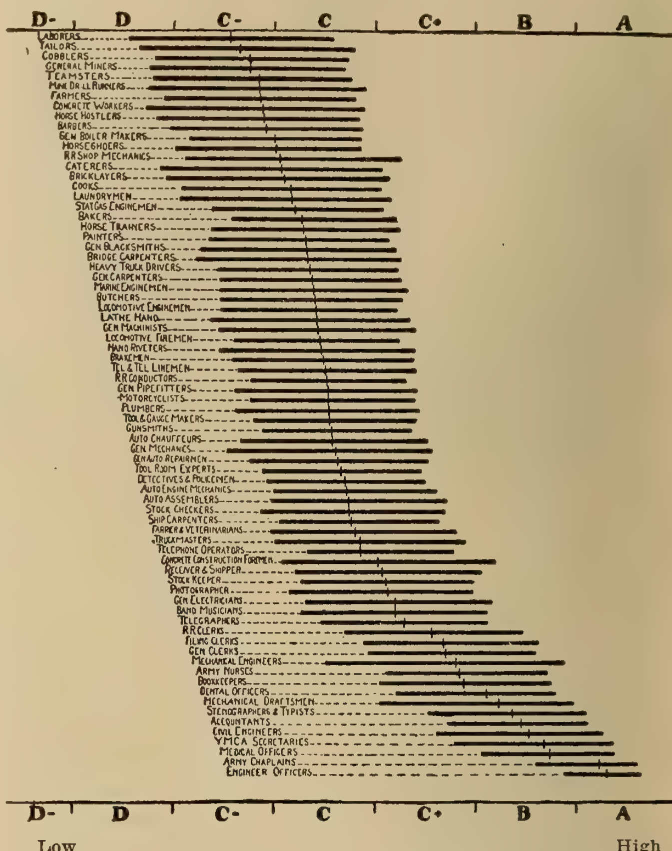
People **hear** with the **eyes** **ears** **nose** **mouth**

The correct word is ears, because it makes the truest sentence.

In each of the sentences below you have four choices for the last word. Only one of them is correct. In each sentence draw a line under the one of these four words which makes the truest sentence. If you cannot be sure, guess. The two samples are already marked as they should be.

SAMPLES { People **hear** with the **eyes** **ears** **nose** **mouth**
France is in **Europe** **Asia** **Africa** **Australia**

It is well to recall here that intelligence is not the only form of natural capacity and also that it does not necessarily measure the amount of specific information and special skill that may have been acquired. It is a legitimate question, then, to ask: What is the value of the intelligence task as a vocational guide, even if it is developed to perfection? The following chart taken from a report of the Surgeon General's office of the United States Army, showing the relation between intelligence and occupation in the case of 36,500 men, will help us in answering this question.



BRAIN POWER OF MEN IN DIFFERENT OCCUPATIONS[2]

Along the left-hand margin of the chart will be found the names of various occupations. The intelligence of the men in that occupation in the army is indicated by the horizontal line following each name. The length of this line and its relation to the A, B, C, etc., scale at the top and bottom of the chart shows the range of intelligence of the middle fifty per cent of the men in any occupation. For example, if the laborers are arranged in a row according to intelligence from the lowest to the highest, the first line in the chart will indicate the range of intelligence from the man one-fourth of the way from the bottom to the man one-fourth of the way from the top. The short vertical line cutting the horizontal line shows the intelligence of the middle laborer, namely C—. A casual examination of this chart shows that different occupations represent different degrees of intelligence. But it shows also that these differences among neighboring occupations on the chart are too slight to be of service in vocational selection. For example, the occupations from horseshoer to telephone operator all have the individual representing the middle of the group falling within the C class.

It is not by any means true that the best worker in any occupation is the person of highest intelligence. It is quite possible that for certain occupations a rather low grade of intelligence is adequate, and that to employ one of a higher grade of intelligence would be an economic waste. The determination of the minimum intelligence required to do satisfactorily certain kinds of work is an important problem, and the matter is being carefully studied. These studies may eventually enable the state to make its mental defectives economically independent by putting them into the type of work for which their capacity fits them.

Furthermore, intelligence is not the only trait required for

[2]Reproduced from "Industry, Emotion and Unrest," by Edward Thomas, published by Harcourt, Brace and Howe.

success in an occupation. Honesty, punctuality, loyalty, general health and many others may be indispensable. The best intelligence examination now in use for measuring fitness for entrance into college shows only sixty per cent of a possible perfect relation between performance in the test and academic record during the first year of college work. An authority on the use of such tests has stated that the relation could not be expected to be closer since success in college work depends on so many other traits besides intelligence. If that is true of college work, how true must it be of the majority of the vocations?

TEST FOR SPEED AND ACCURACY OF MOVEMENT AND STEADINESS

The needle makes an electric contact if it touches the hole. The thing is to put the needle in the hole without making contact

The measurement of these important traits of character, as we have called them, presents a difficult problem. Psychology has contributed somewhat to the analysis of these traits, but its main contribution consists in furnishing a method which shall make people's judgment about them more reliable. Such traits manifest themselves in a social environment only, in the behavior of one person toward another. Kindliness means the impression that we make upon other people in one respect, sociability, pugnacity, etc., the impressions that we make in other respects. They can mean nothing else. So to measure such traits we measure the impressions that others get of a person.

Psychological studies have shown several important facts about such judgments. First, there is safety in numbers. If one person's estimate of an acquaintance in regard to honesty has some reliability, the combined estimates of a dozen persons will have greater reliability. Knowledge of this one fact may do much toward improving methods of vocational selection. It has been found that if letters of application for a position are judged by ten people instead of only one, the combined judgments provide the more accurate measure of fitness. Second, some traits of character can be judged more accurately than others. To make a general statement about the matter, it may be said that those character traits which can manifest themselves in some objective form are most accurately judged, while the more strictly social traits are least accurately judged. Thus honesty and aggressiveness represent the former class and beauty and kindliness represent the latter class. Third, the estimate of oneself has some value. The statement has been made by one investigator that a person can judge himself better than anyone of his friends can, if he sincerely wants to do it. And he should be able to judge himself best in the traits in regard to which his friends have most difficulty in judging him. Sets of questions have been prepared with which anyone can make such a self-examination.

There has recently come to the writer's attention a system for vocation selection in which estimates are required for 350 separate traits and the final record for an individual is determined from one person's estimate of himself plus that of four of his acquaintances. This form of character judgment by oneself and his friends is quite different from the systems which depend upon the examination of anatomical features and proportions or upon snapshot observations of facial expression or more general bodily behavior. Such systems are based upon hypotheses that are not accepted by science. They flourish for lack of better ones, and simply bear witness to the great need of adequate measures of character. The degree to which one possesses a certain character trait is usually expressed in terms of percentages. For example, in what per cent of all the chances that one has to show benevolence does he really show it; of a hundred chances to show one's honesty, how many chances would be accepted? This is a very simple method of estimating. Another method, somewhat more elaborate, formed the basis for the rating scales used in the U. S. Army for estimating efficiency and other traits. Each rating officer prepares his own measuring scale for each trait as follows: In the case of "value to the service," he would put at the top of the scale the name of that officer who he thought possessed the highest value (100%); at the bottom of the scale he would place the name of that officer who represented a minimum value to the service (0%); others possessing intermediate degrees of value would be placed in appropriate positions between these extremes (25%, 50% and 75%). After the scale was thus formed, any officer could be judged by comparing him with the men representing the different points on the scale, and by giving the appropriate per cent rating. Ratings from a number of judges can easily be combined, for although the points on the different scales are not represented by the same individuals, still they represent for all judges the same degrees of value. These measuring methods are being introduced into business and industrial organizations.

Tests for measuring *special* natural traits or capacities were the first to be developed. Francis Galton, as early as 1880 prepared a test for measuring capacity for getting mental images of objects. Following Galton there were devised special tests for attention, perception, speed and accuracy of movement, keenness of vision and hearing, sensitivity to changes of position of the body, sensitivity to color, to differences in the pitch of tones, etc., until today there are hundreds of them.

MEASURING SPEED OF REACTION WITH THE HIPP CHRONOSCOPE

The interval between the sounding of a signal and the touching of a key by the subject is measured in thousandths of a second

Many have special significance for vocational fitness and are used in the selection of typists, stenographers, clerks, salesmen, telephone workers, railroad engineers, and machine workers of various sorts. The accompanying photographs show some of these tests being administered.

Many of the tests for special capacity are so-called paper tests, because the only materials needed are pencil and paper. Brief samples of these will illustrate their nature:

Number Checking Test in Which Certain Numbers or Pairs of Numbers Are to Be Checked as Rapidly as Possible

Form A

4 5 8 7 9 2 3 6 0 1 7 4 1 8 6 0 5 9 2 3 5 9 6 0 8 4 2 3 1 7 8 2
1 3 0 7 5 6 4 9 4 5 8 2 7 6 3 9 0 1 7 6 0 8 4 3 9 5 1 2 1 9 4 7 2 5
0 8 3 6 3 6 4 5 7 0 1 2 9 8 6 5 2 8 3 9 4 0 1 7 2 3 7 6 9 4 1 8 5 0

Form B

215864	**381592**	**826739**	**967814**	**371245**	**942861**
876395	**269517**	**712983**	**368459**	**326748**	**258647**

Directions Test, in Which the Printed Directions Are to Be Followed as Quickly as Possible

1. Write any number larger than 16
2. Add one more dot to the largest group . ... ..
3. Put a cross over the angle that opens downwards V Λ

Addition Test, in Which Each Number Is to Be Added to the Following Number or 17 to Be Added to Each Number

Kraepelin Form	*Constant Increment Form*
4	32
9	47
3	21
8	53
6	39
5	28
2	65

Association Tests in Which the Part of Speech Required by the Instructions Is to Be Supplied as Quickly as Possible

Opposite Tests

better
glad
straight

Logical Relation Tests

vb-obj	*supraord*	*subord*	*pt-wh*
cut	horse	flower	roof
buy	Paris	lake	tail
bend	potato	game	Germany
wh-pt	*agt-act*	*act-agt*	*att-subst*
wheel	train	shines	cold
Europe	frog	howls	cheap
brush	sun	crawls	narrow

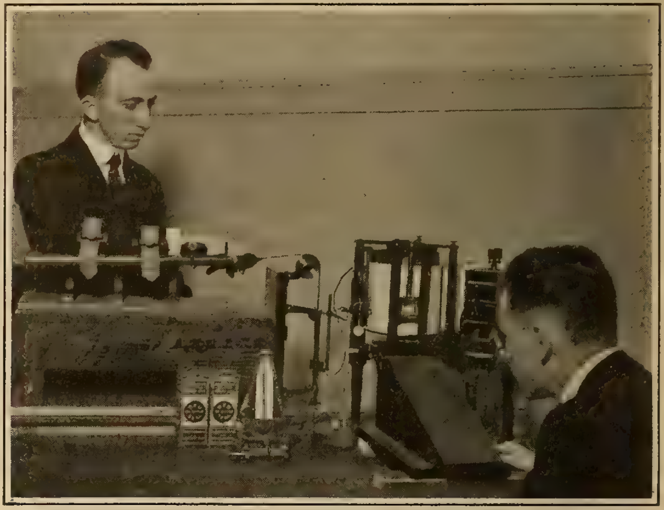
Mixed Relations Test

Box—square	Orange—
Woman—husband	Man—
East—west	Day—
Penny—copper	Nail—
Asia—China	Europe—
Grain—sand	Drop—
Am—was	Have—

Free Association Test

fox	grass
apple	quick
fork	cure

The great difficulty that is met in preparing tests for special abilities is to determine just what special abilities are required to do a given task. What to the layman may look like a very simple operation may from the psychological point of view be divisible into fifteen or twenty special functions. We are accustomed, for instance, to speak of musical ability as a kind of special possession. The study of this ability by a psychologist has resulted in its division into at least thirty-five special traits, each of which is of importance in determining the musician's ability. Tests for these traits have been standardized and some of them have been arranged on phonograph records, so that anyone can without particular training get an approximate measure of his sensitiveness to differences in pitch of tones, his sense of rhythm, his memory for tones and his sense of harmony. If the records of a person in these



MEASURING FATIGUE BY MEANS OF THE MOSSO ERGOGRAPH TO TEST MAN'S ENDURANCE

tests are expressed in terms of per cent of the maximum degree to which this trait may be possessed, a chart may be constructed which will show at a glance a kind of picture of his capacity. Such a chart is called a psychograph, and a short psychograph of musical capacity is shown in the accompanying figure.

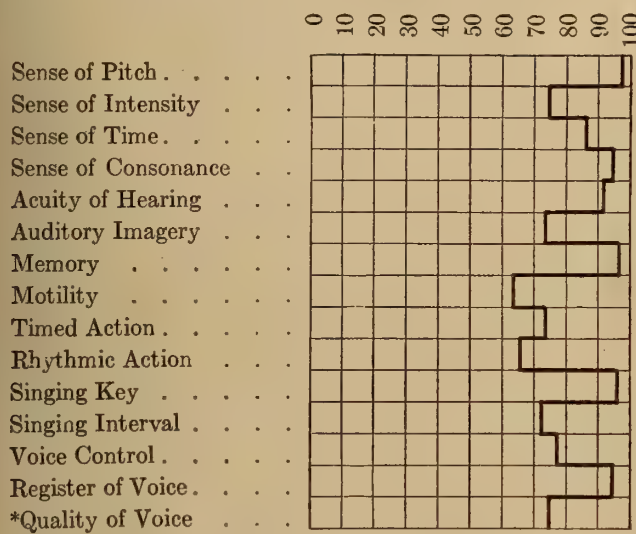
The work of telephone operator may be similarly broken up into a group of special abilities, and the psychological tests

THE GALTON BAR WHICH IS USED TO TEST THE PERCEPTION OF SMALL DIFFERENCES OF LENGTH

devised to measure them may bear little or no resemblance to the actual work done by the operator. Some of these tests are the perception and association tests previously described. In some cases the work defies psychological analysis and a different method of testing has to be resorted to. A large number and variety of tests are prepared and tried upon operators of various grades of ability as measured by their actual performance in their work. Those tests which the good

operator can do well, and which the poor operator can do only poorly, and which the average operator can do moderately well are chosen as measures of this particular capacity. This is known as the correlation method. It is a strictly empirical method and rests upon no previous analysis of the job. Many splendid results have been obtained by this method in measuring complex capacities as stenographic ability.

The remaining types of tests, the educational and the trade tests, are psychological only in the sense that the methods that are used are psychological. The ordinary school examination, if the questions are prepared and the answers scored according to psychological principles become psychological tests. The information and skill tests which are becoming so



A PSYCHOGRAPH OF MUSICAL CAPACITY[3]

useful in industrial work are psychological in this sense also. The measures of native capacity are, however, most commonly thought of as psychological tests. There are so many forms and varieties of mental measure that one can no longer speak of "the psychological examination," but must distinguish some special form of it. Every conscientious writer upon the subject of mental measurement realizes that the study and preparation of such tests has only begun, and feels constrained to warn against expecting more at present than can be accomplished. No one familiar with the field of mental tests doubts the position of importance they will occupy in the future. The only danger at present lies in the indiscriminate use of the tests by persons not qualified to administer them and in cases where their application is not justified. As measuring devices for a serious purpose they can be used only by those who understand their nature and recognize their limitations.

SPEAKING WITHOUT A LARYNX

Since the larynx is the chief organ of speech it might well be supposed that its loss through accident or disease would involve muteness. However, a French physician, Dr. Sébileau, an associate professor of the Paris Faculty of Medicine, recently exhibited one of his patients to the Society of Surgery, whose larynx he had entirely removed some fifteen years previously. The patient had retained of his entire physical apparatus, only the resonance chambers. Yet singular as it may seem the victim of this misfortne had acquired the power, after five years of steady effort, of speaking well enough to be understood without trouble and with sufficient force to be heard at a distance of 10 to 15 meters.

Dr. Sébileau explained to his audience that since the pulmonary apparatus is unable to act as a reservoir of air, this function is fulfilled by the activity of the pharynx, and possibly even by the œsophagus and stomach. The supply of air is probably obtained by swallowing. In order to transform the activity of the œsophagus and pharynx into that of a bellows and to maintain therein the air at a pressure capable of producing physical sounds approximate to normal, the indispensable hermetic occlusion is obtained by bringing near each other the epiglottis, the base of the tongue, and the pharyngeal muscles. When he wishes to talk the subject first presses the base of his tongue vigorously against the velum and then lowers it suddenly, giving an exit to the air enclosed within the pharyngeal cavity, while the epiglottis, the posterior columns, the lips and the tongue perform the motions required to enable the cavities of resonance to perform their usual function. In Dr. Sébileau's opinion the posterior columns of the epiglottis act as vocal cords. During the utterance of the open vowel *a*, for example, the columns and the epiglottis are held taut and possess a vibratory movement; they thus help to form the fundamental note which is then modified by the harmonies of overtones produced by the cavities of the mouth and nose.

The voice thus produced is not quite natural in sound, it is rather hollow sounding because of the insufficiency in the character of both the fundamental and the overtones. The epiglottis and the palate and its movement form a long soft reed pipe and this produces a tremolo voice. Furthermore, the subject is unable to modify either the timbre, the height, or the intensity of the sound. He is unable either to whistle or to whisper—however, he is able to blow out a candle.

Two interesting deductions are derived from this case. In the first place it seems evident that persons having suffered such an injury can recover their power of speech to a considerable extent by undergoing a special training. Furthermore, the case shows that speech is a more complex phenomenon than had been supposed, it indicates, for example, that the upper respiratory passages play a much larger rôle in speaking than had been thought. Light is thrown, too, upon the imperfections exhibited by the speech of certain deaf mutes, who have been artificially trained to speak. Perhaps, too, we have here the key to the theories explaining the much debated phenomenon of ventriloquism.

THE THERAPEUTIC VALUE OF SILICIC ACID

A German physician has recently directed attention to the remarkable curative action exerted upon wounds by silicic acid. Writing in the *Zeitschrift für Balneologie* he observes that numerous experiments have firmly established the fact that silicic acid, which is always present in the body, is very closely related to connective tissue, so closely related, in fact, that the content of silicic acid in the organism is directly dependent upon the amount of connective tissue present and *vice versa*. Hence the silicic acid may be regarded as the chief means of functioning of active tissue. But the silicic acid of the body not only stimulates the formation of active tissue but also greatly increases the number of white blood corpuscles or leucocytes. It is a well-known fact that the leucocytes possess two important functions with regard to the preservation of the health of the organism. By their phagocytic power they directly destroy bacteria which have succeeded in penetrating the body and, furthermore, they produce protective substances called leucines in the tissue fluid which also have bacterial action; the greater the number and the more rapid the production of the white blood corpuscles the more active is the passage of the leucines into the tissue lymph. In spite of aseptic treatment wounds often become inflamed for one reason or another, and in such cases the addition of silicic acid is found to exert a very favorable influence upon the process of healing. The investigator remarks that among the various preparations of this acid, none so far has been produced which is entirely free from objection, consequently he advises its use in the form of its solution in natural mineral waters.

[3]Reproduced from the Psychology of Musical Talent, by Carl Emil Seashore, published by Silver, Burdett and Co.

Chemical Construction and Individuality*

New Light Thrown Upon the Enigma of Specificity by Chemical Analysis and Research

By H. Bierry, D. Sc.

Head of Lecture Department of the École des Hautes-Etudes

ONE of the characteristics of living creatures is their individuality. Even if there is practically no difference between two living beings, their individuality is, nevertheless, discernible; in other words, they form two distinct entities. Even though an organism must develop along a definite line indicated by the heredity which obliges it to reproduce a type of its race, it none the less remains a definite unit, distinct both from its ascendant relatives and from its descendants. . . .

Living organisms may be considered from two points of view—that of their form and that of the concrete qualities concerned in what we call "life." For a long time it was the form alone which was the subject of special study; as a matter of fact, indeed, there is nothing which gives a better idea of the individuality of the living creature than the typical form it possesses. Thus we find that, to begin with, the sciences of zoölogy and botany devoted themselves exclusively to the study of descriptive characteristics: the external configuration, on the one hand, and the internal or *physical structure*, on the other. The next step was taken by general physiology, which revealed to us the existence of a common foundation forming the basis of living forms under various disguises. Finally, chemical analysis by showing individual variations of composition has revealed the vast importance of *chemical structure*.

It was Armand Gautier who first brought this subject into the field of experiment by his researches with respect to *Vitis vinifera*, finding in the different chemical nature of the constituents of cells, the profound causes of those morphological diversities which the naturalist classifies in his ideas of species, families and races. This view is shared, likewise, by A. Prenant and E. Lambling. La Dantec is of the opinion that there is "a definite relationship between specific form and chemical composition—in other words, that the chemical composition indicates and directs the specific form taken by the organism." In a recent book Jacques Loeb states his conclusions concerning this matter in the following words: "Specificity is determined by specific proteins, while at least some of the Mendelian characters appear to be determined by hormones or by enzymes which are not specific for the species or for the genus."

But even if the problem of the living *form* as held by Albert Dastre cannot be entirely reduced to the same terms as the problem of living *matter*, even if this form must be considered to represent "the condition of material equilibrium corresponding to a very complex situation, to an ensemble of given conditions," in the present state of scientific opinion, it is difficult to avoid the assumption that the chemical condition must be a factor of preponderating importance and that the specific form of the organism must be connected, at any rate in very large part, with the chemical structure.

Even if all vital functioning is merely, as is believed, the resultant of intimate actions in relation with the integrating molecules of protoplasms and the state of so-called "activity" of these molecules—for it is only in some such manner that we can conceive of elementary phenomena—it is, nevertheless, quite possible to believe that specificity or individuality is more or less chemical in nature not only as regards function but with respect to external aspect. According to this theory, changes of form must result from molecular modifications—in other words, it is through the nature and the arrangement of the molecules which constitute the elements of the structure that we must seek to understand the peculiar functioning of the various tissues.

Having once accepted this point of view one is tempted to go still further and to inquire whether there may not be some analogy of configuration between the organic elements and those stimulating secretions or excitants, some of which have an indisputable analogy of configuration[1]; in other words, one which may be compared to that held by E. Fischer to exist between the diastase and the asymmetrical body[2] which the former attacks. We should have difficulty, indeed, in forming a concept of the definitely elective action exerted by the hormone, except through this idea of an analogy of structure between the anatomical substratum and the corresponding hormone. How otherwise can we explain the extremely delicate sensibility of certain muscular or nervous fibers to the action of chemical substances (Dale and Laidlaw) which merely approximate certain groups of atoms.

But let us return to the subject of our special concern and seek to discover among the numerous component elements of living creatures whether there be not some substance or some group of substances which may be considered as forming the basis of specificity, *i.e.*, by which the individual is characterized.

The works of Hopkins, of Osborne and Mendel, and of McCollum have demonstrated, by establishing the close relations

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[1]A striking illustration of the part played by a given group or a given function in the molecule of the chemical stimulant is afforded by the effect exerted upon the terminations of the sympathetic nervous system by adrenalin and analogous substances (arterenol, adrenalone, etc.) which are classified as being more or less "sympathomimetic," according to the degree in which their structure approximates that of adrenalin. . . .

Abderhalden's studies with respect to cases of true hermaphroditism are still more suggestive. Certain pheasants have been produced whose plumage is that of the male upon one side and that of the female upon the other. On that side of the bird having the male plumage there is a testicle while upon the other there is an ovary; but it is a well-known fact that the secretion of these two organs exerts a direct influence upon secondary sexual characters and upon the plumage in particular. It is quite certain that these two sorts of secretion are furnished indiscriminately to each side of the body of the bird and we are obliged to believe as E. Lambling has pointed out that the chemical nature of the protoplasm plays a definite part in the matter; but it is difficult entirely to explain the fact unless we assume that there is an analogy of configuration between the anatomical substratum of the male side and of the female side respectively, and the corresponding stimulant secretions.

[2]There are a number of diastasic actions which require a close collaboration between the enzyme and some special chemical substance, as in the case of Laccase and manganese, trypsin and calcium, amylase and electrolytes, maltase and the chlorine ion, etc. *By analogy we are justified in supposing that certain special chemical substances are required for the action of certain hormones and that certain vitamines may play such a part.*

Let us consider in this connection cases in which animals are supplied with food entirely lacking in vitamines: In the first phase of the experiment no particular symptom and no characteristic disturbance is to be observed; afterwards in the second phase the symptoms of avitaminosis appear, including lack of appetite, nervous disturbances, troubles of metabolism, a lowering of the temperature, etc., while, at the same time, there is an atrophy of all the organs except the supernal glands which exhibit on the contrary, a marked degree of hypertrophy . . . but all of these sysmptoms can be made to disappear in the course of two or three days, provided that suitable vitamines are supplied. . . . These facts are readily explained if we suppose that the vitamines play a definite part in the action of certain hormones. . . .

Apparently the vitamines present in various animal tissues are to be regarded merely as reserves capable of being utilized by the organism. The creation of vitamines appears to be accomplished solely by certain bacteria (Bottomley, H. Bierry, and P. Portier, Pacini and Russell).

which exist between the growth of an animal and the molecular composition of the alimentary albumens, that evolution has been governed up to a certain point by chemical structure; however, experiment has not proceeded further along this path. It is only when we turn our attention to the comparative biochemistry of species and of tissues that we can succeed in finding groups bearing the specific imprint or trade mark, so to say, belonging to the species, since hitherto it has been found impossible to modify specificity by experiment in any permanent fashion. It is true, perhaps, as Schaankervitsch holds, that it is possible by modifying the external milieu to transform the *Artemia salina* into the *Branchipus stagnalis*—but this fact is a matter of dispute.

BASIC ELEMENTS OF ORGANS AND TISSUES

According to the accepted belief the fundamental elements of organs and tissues consist of protein, fats, and carbohydrates combined with each other and with mineral substances: glyco-proteids, lipoids, nucleo-proteids, etc. We also find within the tissues the products of cellular activity—the hormones and the diastases.

If we suppose that the general chemical specificity of an organism is composed of all the special chemical specificities possessed by the various differentiated tissues, then it would seem at first glance that the nucleo-proteids which form a portion of the nuclear chromatic substances and of the chromosomes (. . . which are regarded as the carriers of hereditary characteristics) ought to exhibit remarkably definite chemical properties. But this is not the case.

The methodical laboratory tests made by Levine to which we owe our most recent information concerning the "*nucleotids*" have shown that the nucleins, the lipoids, which are present in all the organs of all the species, and the conjugated sulphuric acids . . . exhibit an invariable structure. Consequently, Levine seems driven to admit with Jacques Loeb that these bodies do not determine specificity and are not the carriers of the Mendelian characters.

The Albumens.—This brings us to a study of the albumens, which are held by Loeb to be the "carriers of the specificity," and among the various albumens in the body he examined particularly those of the *vital milieu* also known as the *internal milieu*.

This milieu, which in complex organisms consists of the blood, the lymph, and the interstitial liquids in which are immersed the actually living protoplasms, is definitely distinct from the *cosmic milieu* or *external milieu;* this internal milieu also exists, but in a much less complex form among many of the protozoa and the bacteria. The higher the organism in the scale of life, the more fixed the nature of this vital milieu and the more independent it is of the external milieu; because of this very degree of perfection its physical and chemical composition in the higher organisms is capable of varying only between narrow limits. . . . This is what we mean when we say that each individual has its own *specific milieu*.

While the cosmic milieu is the common environment of all creatures each separate organism must elaborate its own vital milieu. Indeed, one of the peculiarities of living creatures is their capacity for synthesizing their own peculiar substance from foreign elements, and in particular from the albumens of the *blood plasma*.

The Sanguine Plasma.—From an anatomical point of view the plasma is a saline liquid containing albumen and sugar and holding in suspension the red and white corpuscles—thus constituting the blood. From the physiological point of view it is the medium which enables the organism to make exchanges of matter between its own organs as well as with the cosmic milieu. It receives the materials of nutrition and delivers them to the various tissues; the latter, in their turn, pour forth into the plasma the various products which they have elaborated, together with the waste matter which must be got rid of. . . .

Upon analysis, as we shall see, the plasma is nearly always found to be composed of the same basic substances in practically constant quantities. This uniformity is obtained by means of the very delicate and perfect mechanisms which strictly regulate its composition. This uniformity of constitution is only approximate, however, since the immediate principles which form the tissues are constantly undergoing disaggregation, while new amounts of the same substances obtained from outside sources enter the plasma and are introduced into the eternal cycle of vital operations. These two processes of destruction and renewal are always associated and reciprocally operative.

The plasma, then, is the milieu wherein there is an equal equilibrium constantly aimed at between the new materials provided and the used up materials of worn-out structures.

Let us now consider certain experiments which have revealed to us the fixed nature and proportions of the albumens of the plasma. In one experiment a horse was freely bled a number of times, being fed between times with a special albumen called gliadine, containing 45 per cent of glutamic acid; yet at the last bleeding the proteins in the plasma of this horse contained merely a practically normal percentage of glutamic acid (Abderhalden).

But it is even possible to go still further and to remove from an animal a really enormous quantity of plasma provided there be injected without too long a delay, corpuscles in a physiological saline fluid; in the case of a dog bled in this manner the plasma is found to have regained its normal content of proteic substances at the end of two days, and this even when the dog had received no food (Morawitz).

It is evident that the organism must have at its disposal very varied resources to enable it thus to keep its plasma supplied with an adequate amount of albumenoid substances in spite of a great diversity of food and even in spite of actual starvation. . . .

Formation of the Albumens.—After *digestion* which consists largely of a methodical cleavage (though it has not been proved that the molecular dislocation is entire), and *assimilation* the various fragments first form peptid combinations and then suitable albumens of various forms capable of taking part in the activities of the body: protoplasmic forms meant for the reconstruction of cells or the formation of new cells, plasmatic forms constituting the internal milieu, and special forms which have been described by Voit and by Rubner. Among the elements prepared by the digestive process and transported by the blood, the various tissues chose what they need and produce certain transformations (Van Slyke and Meyer, Folin and Denis). It must not be forgotten that the degradations of the proteins of the fats and of the carbohydrates occur simultaneously, so as to produce substances which react upon each other, so that we must consider the albumenoids of the blood plasma as resulting from a reconstruction of the products of digestive hydrolysis subsequent to the exchanges and combinations which occur within the tissues.

A proof of these complex combinations is found in a hydrocarbon group in the proteins of the plasma, which has been found, even in an animal fed only with proteins deprived of the sugar group—and even, in fact, in an animal which has received no food at all. This indicates that we must not regard the albumens of the blood plasma and the albumens of certain tissues as being "neutral" proteic substances, as has been held; we must look upon them on the contrary, as substances possessing many chemical affinities and always ready to take part in chemical reaction. We must think of these molecular structures, therefore, not as rigid blocks, but as plastic combinations, whose stability is governed by reciprocal balances, and which are, by that very fact, fitted to play their part in the incessant mutations which occur within the organism.

Let us next inquire whether digestion and assimilation result in the formation of albumenoids specific to the species, and, more particularly, to the individual.

The organism does not allow its vital milieu to be entered except by materials which have been deprived of the specific characters of a foreign species whence they proceed; furthermore, it tolerates only substances presenting an adequate form . . . if, for example, we introduce in a roundabout manner into the internal milieu of an animal, nucleo-proteids derived from the albumens of foreign tissues or even from the tissues of the animal itself, substances which would produce no trouble when swallowed *per os*, disturbances at once occur and what are known as "cytotoxic functions" immediately make their appearance in the plasma, forming an indication of the presence of the corresponding *diastase of defence* (H. Bierry and A. Pettit, Pearce, Fiessinger). We may look, therefore, to find a specificity in the albumens of the plasma, a fact which is betrayed by certain biological reactions including phenomena of precipitation and of anaphylaxis.

It is a well-known fact, on the one hand, that when we inject, a number of times, under the skin of an animal an albumen borrowed from a different species—if we inject a rabbit with horse serum, for example—then the serum of the animal which has undergone the injections will acquire the power of precipitating the injected albumen. This reaction is called the *formation of precipitine*, but this precipitation is *produced only by the serum of the horse*, it is not produced by proteic substances other than those contained in the serum. *However, a rabbit serum which precipitates the albumen of horse serum will also precipitate the albumen in the serum of an ass or of a mule.*

Moreover, if we inject horse serum into the veins of a rabbit no disturbance occurs, but if the injection is made into a rabbit which has previously received horse serum injected beneath the skin (two or three injections a week apart) disturbances are produced which bear the name of sero-anaphylactic disturbances and which may be serious enough even to cause death.

These biological experiments clearly show that there is a *zoölogical specificity*, a specificity of origin—*i.e.*, the definite mark imprinted by the species—in the albumens of the blood plasma. By modifying certain proteins by the action of various substances, such as diastases, oxidizing agents, etc., and employing them in the biological tests described above, we can produce or not produce, as the case may be, these reactions of precipitation or of positive anaphylaxis. Thus certain primary proteoses, which have retained the amino acids of the primitive molecule with their particular grouping, do not react in this manner; this affords proof that these biological reactions are determined not only by the presence of certain groups in the molecule but by the configuration of the said molecule itself.

Having proved our first point let us now inquire whether there be in the composition of the proteins of the plasma some element or group of elements which varies constantly according to the species and to the individual, and which we may, therefore, consider as being a *biological characteristic.*

Glucose.—Glucose is found in the blood plasma of man and of various animals including mammals, birds, reptiles, batrachians, fishes, etc., in two forms—in a natural state and in a state of combination. In the latter case its presence cannot be manifested until after the breaking up of the complex molecule which contains it and which adds its aldehydic function. These are the proteins of the plasma whose molecules contain the combined glucose which is known as *proteidic sugar*. This proteidic sugar exists in greater or smaller amounts in the albumens of the various sorts of plasma and it is possible to prove that there is a definite relation between the percentage of this proteidic sugar and the amount of nitrogen contained by the proteic substance; hence this percentage can be used to calculate the entire amount of the aforesaid substance.

Special research upon this subject has shown that *each animal species possesses a blood plasma consisting of a special albumen*, as can be shown by a study of the ratio of the content of the proteidic sugar and the nitrogen, which differs for each species (H. Bierry and Albert Ranc).

This ratio determined for arterial blood is approximately 3 in fowls, 6.5 in horses, and 8.5 in dogs; it varies in much more narrow limits in individuals of the same species—for example from 2.9 to 3.5 in fowls, from 6 to 7 in horses, from 8 to 9 in various dogs—but it exhibits in the same individual a manifest constancy, at any rate at intervals of several months and under the same conditions.

Special Albumens and Individual Plasmas.—We are justified in stating, therefore, that the plasma of each individual contains a given percentage of a special albumen, suggesting that the organism supplies its various cells not only with proteins of a special nature but with definite proportions of these—that there is, in a word, an *individual threshold.* There is such a threshold likewise in the higher organism for water, for fatty and lipoid substances, for free sugar, and even for temperature; we also find in these higher organisms an entire series of functions designed to maintain physical and chemical conditions. "These vast synergetic actions," writes Albert Dastre, "which must be regarded as primordial functions—respiration, circulation, and the excretion of waste matter, find the reason of their existence in the regulation of the internal milieu."

This is the *law of constitution of organisms* enunciated by Claude Bernard. According to the view held by this authority, nutrition, taking the term in its widest sense, requires first an organism—atavistic protoplasm—and a suitable milieu, and life is the result of the conflict between the living particle and the medium which surrounds it. But in direct proportion as we advance in the scale of life, we find an increasing stability of the vital milieu as compared with the anatomical elements whose protoplasmic composition is likewise perceptibly fixed; this slight variability of the two factors of the so-called "vital conflict" forms an expression of the close chemical bonds by which they are united and which permit the passage from one to the other of the proteins in particular. This suggests indeed the existence of common chemical nuclei.

The idea of the specificity of the plasma carries with it the idea of the varieties of plasmas equal in number to the variety of species and of individuals. Together with a common vital basis, the individuals of the same species may exhibit plasmas differing from each other by infinitesimal shades. Conceding this to be true there is no better way to define the individual than by a knowledge of its vital milieu, since strictly speaking there is none other which is precisely the same. . . .

Still other proofs may be offered as revealing the specificity of sanguine plasmas—proofs derived from the transfusion of the blood and from animal grafts as shown in experiments by Christiani Nageotte, L. Loeb, and Krawamura; but to follow these would carry us too far.

CONCLUSION

The facts set forth above constitute biological and chemical proofs in support of the idea that individual differences exist between the proteins of the blood plasmas of various animals, and it cannot be doubted that the albumens of the plasma must be regarded as among the carriers of specificity and individuality. The facts cited furnish as yet only general indications, but it is allowable to suppose that a more intimate chemical study will reveal affinities and differences which inevitably escape the students of morphology; and it is fair to suppose that methods of chemical research which extend even to the molecules of which protoplasms are composed will lend assistance to the solution of the enigma of specificity and individuality.

THE TERCENTENARY OF THE POTATO

In 1621 the governor of the Bermudas sent to the governor of Virginia, two large cedar chests in which were plants and fruits and vegetables, known to the coral islands, but not to the mainland. This event will be celebrated next December, for the potato was one of the best contributions.

REPRODUCING AN ENORMOUS DEVIL FISH AT THE AMERICAN MUSEUM OF NATURAL HISTORY

The Monster Devil Fish

Curious Habits of the Manta—A Gigantic and Powerful Marine Ray

By May Tevis

HIS Satanic Majesty has given his name to no less than five denizens of the deep sea—all of them as might be supposed from the title "devil fish," creatures of peculiarly fearsome or repulsive aspect. Best known of these, of course, is the giant octopus, whose evil looking head and writhing snake-like arms or tentacles suggest the ancient Greek fable of the snaky-locked Medusa. Other animals to which the term devil fish is applied are the Victorian *Lacepedia charpactra*, the gray whale, the angler, that huge and misshapen creature from whose body extend long filaments by means of which it is supposed to attract its prey, and from which it derives its name, and finally, the great ray sometimes as much as 20 feet broad and 12 feet long, which is the subject of the present article.

As our pictures show the manta is extremely broad and flat, somewhat suggesting a bat with outspread wings. The name manta is derived from a Spanish word meaning blanket while the alternative name devil fish refers to the two cephalic fins, which the creature has the power of rolling up so that they forcibly suggest a pair of short, straight horns like those often pictured as extending from the head of Beelzebub.

Because of peculiar bat-like shape, the manta and its relative the mobula, are sometimes known as sea bats or vampires. C. F. Holder lays special emphasis on the bat-like aspect of these fish, a similarity increased by the fact that the pectoral fins are long and wing-like, and are, indeed, used with a wing-like motion. Holder writes: "In following one another around the circle they raise the outer tip of the long wing-like fin, high out of the water in a graceful curve, the other being deeply submerged. . . . Now gliding down with flying motion of the wings; sweeping, gyrating upward with a twisting vertical motion, marvelous in its perfect grace; now they flash white, again black, so that one would say they were rolling over and over, turning somersaults were it possible for so large a fish to accomplish the feat."

Other observers confirm this statement, averring, indeed, that the fish actually does turn somersaults. The likeness of the motion to flight is increased by the frequent leaping of the fish above the surface of the water. While many persons have declared their belief that the fish actually entirely leaves the water, a recent writer upon this subject, Russell J. Coles, declares this to be a mistake, careful observation having convinced him that only the forward portion of the body emerges from the water. In leaping the manta makes a headlong rush till about half its body is above water, and at the same time it revolves rapidly turning like a wheel on its axle. One pectoral fin disappears under water while the other rises straight up in the air describing the arc of a circle. During this revolution the tail (in the adults) stands rigidly out from the body. A related species, the *mobula olfersi* (also known as a devil fish) leaps entirely clear of the water, sometimes to a height of more than 5 feet in the air, slapping the water with a loud thump when it returns to it.

The Fins.—While devil fishes are relatives of sharks and every gradation of form is to be found between the long narrow bodies of sharks and the broad bat-like bodies of these great rays, the latter use their fins in a very different manner from the former. As we have said, the pectoral fins have a sweep like that of the wings of a bird or bat. But the head fins or cephalic fins are still more highly differentiated; they are, in fact, grasping organs and have a power of rolling upon themselves which has been compared to the curving of an elephant's trunk. These fins are also called arms, feelers, claspers, caropteres and horns. When swimming the fish

plies these very muscular and powerful "arms" with great rapidity in front of its mouth. Since they have an inward motion this action tends to bring food toward the mouth, just as a greedy, small boy might spread his hands apart on a table covered with candy to rake it toward himself. Well authenticated stories are told of cases in which a huge manta has seized the anchor of a boat with these powerful claspers and rushed violently off with it. It seems probable, however, that such an action was not malice prepense on the part of the animal, but resulted from the fact that the natural clasping propensity of the fin caused it to operate automatically upon coming in contact with the anchor. Upon feeling the tug of the line, however, the fish sometimes turns to attack the boat.

VENTRAL VIEW OF THE GIGANTIC DEVIL FISH

The Food.—It was formerly supposed that these animals fed on large fish and there was even an ancient superstition that they sometimes attacked and ate men, covering the body of a swimmer as with a blanket, whence the Spanish name of *manta* As a matter of fact, however, they live chiefly upon shrimps and other crustaceans or on shell fish and such small organisms. In the Gulf of Mexico they are accused of doing considerable damage to oyster beds. It is probably because of the character of their food that their mouths are provided with peculiar organs not found in any other fish and termed prebranchial appendages. These consist of elongated lamallæ somewhat resembling ferns in shape and arrangement but with the leaflets turned back toward the gills. Each of these lamallæ consists of a fold of mucous membrane supported by a cartilage and they are attached to the anterior surface of the branchial arches in front of the organs of respiration. They are not, however, used for breathing, but are supposed to be employed as strainers like the gill-rakers found in the giant sharks, retaining the small animals taken into the mouth while allowing the water to escape. The jaws are supplied with bands of teeth, as shown in our engraving.

REPRODUCTION

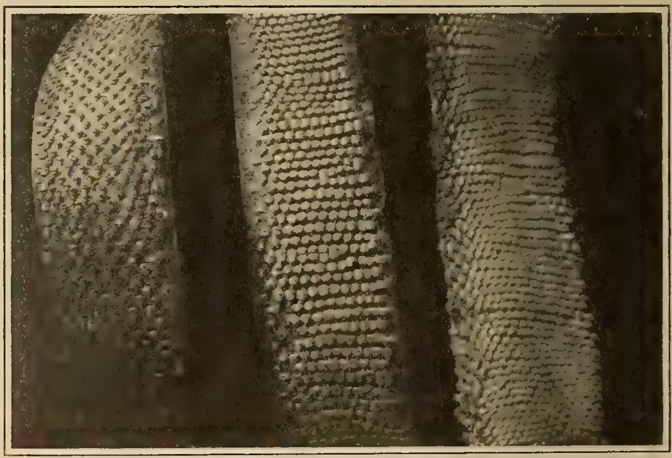
Nothing is more singular, perhaps, in the habits of the devil fish than the method of reproduction. The sexes mate like mammals and live in couples, and the young are born alive like those of mammals, only one being produced at a birth. Strangest of all is the fact that the female produces a nutritious secretion not unlike milk. The mucous membrane of the oviduct is shaggy from the vascular filaments ranged upon it. These contain a milk-like fluid and when examined under the microscope each filament is found to be provided with superficial muscles which, when contracted, serve to squeeze the milk out—a highly convenient self-milking apparatus! Since the embryo has no power of sucking the "milk" out for itself, some such mechanism is necessary. When the young one is examined the mother's milk is found inside the modified first pair of gill-clefts or *spiracles* and also in the intestine. Ichthyologists therefore consider it quite proper to say, in a manner of speaking, that the unborn young fish actually drinks its mother's milk although it does not take it in through the mouth, but, according to Theodore Gill, "by channels homologous with the ear-drum of air breathing vertebrates" (quoting an English authority on the subject, Mr. A. Alcock).

In its early stages the young embryo is nourished from the yolk in the egg sac, just as a young chick is within its shell. The above secretion known as *uterine milk*, is not developed and absorbed until the later stages of the process of gestation. While this "milk" serves the purpose of nutrition, it is chemically different from that of mammals.

The development of the young embryo is undoubtedly like that of all other rays and has therefore some peculiar features. It is very different in shape at first from the parent fish, having instead a form much like that of a shark, its remote ancestor. It has, however, breast fins provided with basilar extensions which are free from the head and which extend forward parallel with the head in front of the eyes. Later, these extensions unite with the sides of the head, thus producing the form of the adult before it leaves the mother's body.

Many observers have noted the very striking and curious fact that when a pregnant fish is attacked the offspring is forcibly thrown out. Russell J. Coles, who captured the magnificent specimen from which our photographs are taken, and which we owe to the courtesy of the Museum of Natural History, gives the following graphic account of such a proceeding. The animal in question was a female 18 ft. 2 in. in breadth and about two thirds as long.) Mr. Cole writes in his *Notes on the Devil Fish*, published in 1916, in the Bulletin of the American Museum of Natural History:

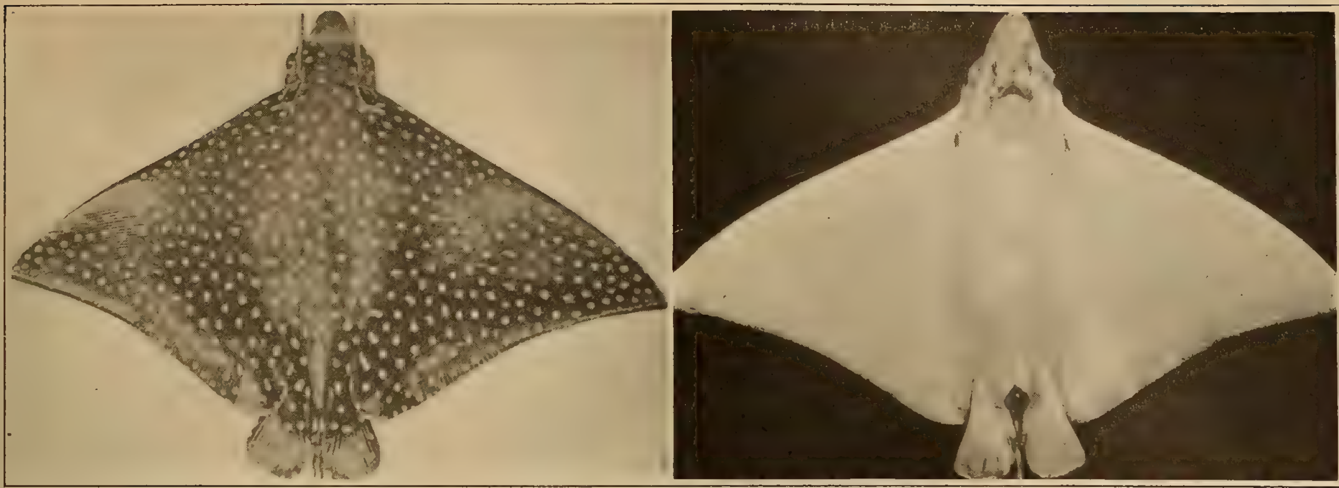
"Almost immediately after being struck by the harpoon the manta made a sidewise revolution along side the boat, and just before the tail had reached the perpendicular an embryo was violently ejected to a distance of about four feet. The



BANDS OF TEETH ON THE JAW OF THE MANTA

embryo appeared tail first, folded in cylindrical form, but it instantly unfolded and its pectorals moving in bird manner retarded its descent until the mother fish had disappeared beneath the surface. I was almost in the act of securing this embryo when it was swept below by a pectoral of the large male mate, which was near the big female. This embryo was well advanced with a width of more than three feet and a tail approximating eight feet in length. An examination . . . showed that the embryo had been contained in the left uterus and the uterine filaments were richly charged with the thick creamy substance absorbed by the spiracles."

The writer has been unable to find out whether this forcible sort of "parturition" or pseudo-parturition is due to an in-



DORSAL AND VENTRAL VIEWS OF ONE OF THE SPOTTED RAYS

stinctive desire of the animal to save its offspring when threatened, or merely, to the convulsions produced by its dying agonies. Apparently, however, it occurs only when the embryo is almost ready for independent life.

While the most recent name for this family of fishes is *Mantidae* (the term employed by Jordan and Evermann) some older authorities prefer the term *Mobulidae*.

The Sounds Produced.—While all devil fishes are characterized by the sounds they produce, there is some difference expressed among naturalists as to the nature of these. Holder speaks of the rushing, swishing thunderous sound produced by the *manta-birostris*, whereas Coles found the startling loudness of the sound somewhat exaggerated. The latter says with regard to the different sounds made when dying, "The dying *mobula* occasionally makes a musical bell-like sound; but three of five dying manta emitted a harsh, bear-like cough." These sounds, of course, must not be confused with the noise made by these fish during their leaping and rushing progress through the water.

The manta belongs to the extensive group of fishes known as the *Raiidæ* which includes the skates and the rays. The great majority of the species in this family belong to the genus *Raia* which lives chiefly in temperate seas, but is more abundant in the northern hemisphere than in the southern, but which approaches the Arctic and Antarctic regions. The top of the body in fishes of this genus is similar in color to the sandy or gravelly bottom where they are in the habit of living, and this camouflage serves to conceal them from the small fishes, crustaceans and other creatures upon which they prey; as the ray is a rather slow and sluggish fish, this concealment is very useful in luring their victims within their reach. Since the mouth is on the under side of the body the ray cannot seize its food as soon as it comes within reach, but is obliged to dart out above it, in which position it can readily devour it. Most of the species have some value as food fishes. The sexes are usually differentiated, not only in size and in color, but in the character of the teeth and also in the presence and arrangement of rows of specially modified spines on the skin of the back.

GASEOUS EXCHANGES BETWEEN PLANT ROOTS AND THE AIR

At the session of the French Academy of Sciences held December 20, 1920, the plant physiologist, M. Raoul Cerighelli, made known the result of his experiments concerning the *relation between the roots of plants and the aerial parts of the same plant*, and also concerning *roots which had been previously detached*. The roots examined were those of plants growing in their natural location or else in cultivated ground, or were taken from plants growing in pumice stone saturated with Knops' liquid. In those cases in which the roots were allowed to adhere to the plant, two series of experiments were made. In the first series the organs examined were luted in the vicinity of the collar (the junction of root and stem) to culture vessels made of inverted lamp chimneys; in consequence of this arrangement their gaseous exchanges took place in the moist pumice stone. In the second series of experiments the organs were also luted to the culture vessel but after the latter had been emptied of pumice stone; the roots, therefore, functioned in a slightly humid atmosphere of air.

In the case of roots previously detached from the air-growing portions of the plant, the same arrangements were made, the roots being likewise placed either in air or in pumice stone saturated with a nutritious liquid. The temperature was kept constant by means of a thermostat, the gas was analyzed by the "method of confined air." Finally, the roots were placed in the dark and allowed to remain for varying periods of time; in the case of adherent roots this period was in some cases as much as 24 to 48 hours. Among the plants studied were the *Senecio vulgaris* L., the *Lupinus albus* L., the *Laurus nobilis* L., the *Sonchus tenerrimus* L., the *Erodium malacoides* Wild, the *Heliotropium europaeum* L., etc. Without going into the details of the various experiments, we may give the results as follows:

1. The respiration of roots takes place like that of the other organs of the plant when placed in a confined atmosphere. There is an absorption of oxygen and a liberation of carbon dioxide in quantities such that the ratio $CO_2 : O$ has a value which varies from 0.7 to 1 according to the species.

2. When the roots are in contact with a very humid atmosphere there is an increase in the respiration: the quantity of oxygen absorbed and the quantity of carbon dioxide exhaled are both greater than in a dry atmosphere, and the ratio $CO_2 : O$ remains constant (in the case of the cut-off roots in the pumice stone).

3. When the roots are in contact with a very humid atmosphere and *are still connected with the aerial parts* there is likewise an augmentation of the respiration, but the carbon dioxide formed during this function is not completely exhaled, and a portion of this gas is drawn upward into the upper portion of the plant, so that the respiratory ratio attains only very low values in these cases. This phenomenon appears to be connected with the absorption of water by the root, since it is the water absorbed which carries with it the carbon dioxide.

The investigator remarks finally that in no case did he discover any absorption of carbon dioxide, at any rate in the gaseous state. He believes, furthermore, that the carbon dioxide having its origin in the roots probably plays a more important part in the plant than the carbon dioxide which is dissolved in the water of the ground and which is absorbed with this water.

A Plant That Feeds on Animals

Bladder-Shaped Structures of the "Water Pipe" which Serve to Trap Insects

MOST of the so-called carnivorous plants, namely, those that trap insects and make use of their juices for their nutriment, are of tropical origin. However, there are a few such as the sun-dew which have the same habit though they belong to temperate zones. One of the most interesting of these is the little water plant *Utricularia vulgaris*, commonly known as the water pipe. This is interestingly described and pictured in a recent number of *Kosmos*.

Upon the delicately divided leaves of the *Utricularia* there are numerous bladder-like structures filled with water which appear to offer a very tempting retreat for the tiny living creatures of the pond where the plant grows, but woe to the water flea or rotiver who seeks refuge in one of these; for these little vesicles are, as a matter of fact, open pitfalls with a devilishly clever device, a sort of hedge of bristles to keep their victims from getting out when they have once fallen in; they are kept captive like mice in a trap. These curious bladder-shaped structures were long thought to be swimming bladders, and there was no suspicion of the fact that they are really animal traps. As shown in our picture (Fig. 1) they are round or oval in shape and provided with a short stem. They are about 49 mm. in diameter. Close examination shows them to be surrounded by a many celled wall (Fig. 3). The mouth is quite singularly formed; the lower lip (*u*) is thick and club-like in shape and furnished with short hairs, whose glands apparently furnish a secretion which serves to attract its victims. The upper lip (*o*) is opposite the lower lip and shuts like a flap (*v*) or valve in the interior of the tube. The entire orifice of the mouth is surrounded by a very forest of appendages or antennæ (*t*), which taken together much resemble a sort of fish weir and probably act in the same manner.

As soon as a water flea reaches the entrance of this little "weir" he is at once conducted to the entrance of the bladder. When he reaches this his slightest motion opens the valve so that he passes straight as a die into the desired hiding place. But once in the elastic door slams shut and since it cannot be opened from the inside the water flea finds himself unable to escape. Moreover his captivity soon begins to be highly uncomfortable, since upon the inner wall of the trap are certain small glands giving forth a sticky fluid, and these open as suddenly as the faucets of a bath tub turned on by an invisble hand and empty their contents into the vesicle. Sooner or later the captive animal is miserably drowned and begins to putrefy. In this latter condition he is just ripe for the table of his host. By means of the short hairs which thickly cover the entire inner surface of the tube the vesicle absorbs the juices set free by the decomposition of the corpse and makes use of them for the nutrition of the plant.

It is really quite astonishing what a large number of animals the plant is able to devour in this ultra-refined manner. Büsgen observed that a moderately large plant in the course of 1½ days captured twelve water fleas with a single vesicle.

The water flea is not the only victim either; the plant also traps grasshoppers, mussel-crabs, rotifers, infusoria and other one-celled animals, plant lice, small worms, and even small tadpoles.

The plant nourishes itself in this manner until early summer; by this time it is in such a well fed condition that it is ready to bloom. It now undergoes a very marked alteration. Up to this time it has had the form of from 8 to 12 meager whorls of leaves unprovided with either roots or stems and blown about by the wind in the upper layers of ponds and ditches. But now it often sends up a leafless green stem as much as 12 cm. above the surface of the pond, with a loose cluster of blossoms at the top (Fig. 2). The small flowers are of a gorgeous lemon color adorned with all sorts of bright spots and streaks. After the petals fall the flower head goes back more or less completely under the water. The flowers are fertilized by insects and bear only a few seeds, so that the reproduction and distribution of the plants is chiefly accomplished by the small winter buds which vary in size from that of the head of a pin to that of a pea, which are formed in the late summer upon various parts of the feathery looking leaves. At the end of the vegetation period these buds drop from the plant and are carried far and wide by the currents of the water. They spend the winter in the mud at the bottom but rise again to the surface in the spring and develop into new plants.

THE RIPENING AND STORAGE OF BARTLETT PEARS

A DISTINCT relationship has been found between the total amount of sugar present in the ripe pear and the temperature of storage at which it had been held from the time of removing from the tree, until ripe. Pears ripened at 70° F. contained the highest percentage of sugar, at 40° the lowest, and those held at 30° from 6 to 14 weeks and then ripened at room temperature were intermediate in amount of total sugar. There was no marked relation between temperature of storage and relative amount of sucrose and reducing sugars. There is a marked and uniform increase in total sugar in the pear from summer until after the time of the close of the picking season.—Abstracted from *Jour. Agr. Research* 19, 473-500 (1920) by *Chemical Abstracts*.

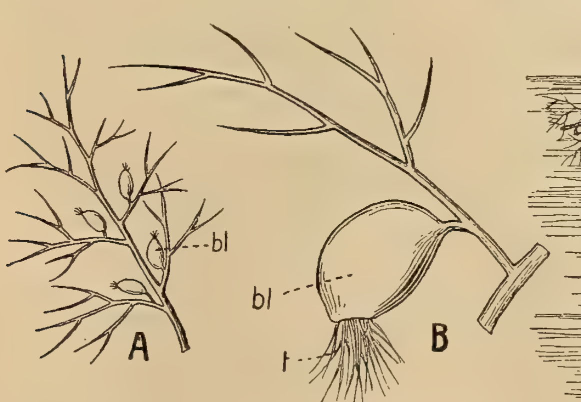


FIG. 1. THE LITTLE VESICLES (bl) WHICH SERVE AS TRAPS FOR INSECTS

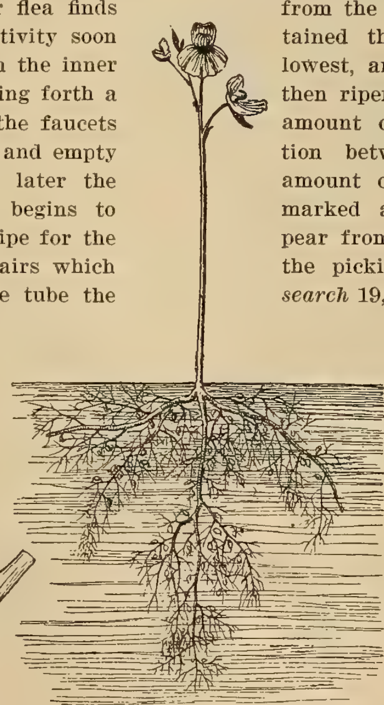


FIG. 2. THE *UTICULARIA VULGARIS* OR WATER PIPE IN BLOOM

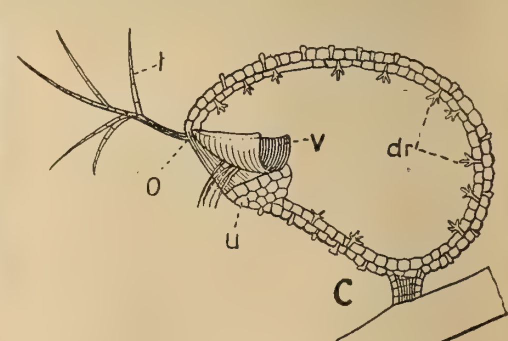


FIG. 3. SECTIONAL VIEW OF ONE OF THE BLADDER-SHAPED VESICLES

Microscopy with Ultra-Violet Light*

Increased Resolution Obtained by Using the Short-Wave Light Beyond the Visible Spectrum

By J. E. Barnard

THE microscope is now so widely used in all branches of science and in industry that it is not surprising to find an increasing demand for greater optical efficiency. It must be admitted that in comparatively few cases is the instrument used under such conditions as to secure the best possible result; but this is due to lack of appreciation of the principles involved, and will be remedied only by a wide educational effort. Even when the greatest optical efficiency is secured, the limitations are soon felt. The chief need is for increased resolution, that factor on which the delineation of minute structure depends. Advances of great value have been made in methods of rendering visible minute objects, but it must be clearly realized that, while this greater visibility can be secured, no information as to the form or structure of objects which are below the resolution limits is to be obtained by this means. Increased magnification is by some workers still regarded as desirable, but unless this is accompanied by proportionally increased resolution, the results are worse than useless, and can lead only to serious errors of interpretation.

Two factors mainly govern resolution—namely, the numerical aperture of the objective, and the mean wave-length of the illuminant. No increase of numerical aperture has been obtained since the classic researches of Abbe, resulting in the production of apochromatic objectives; and in the present state of knowledge there appears little likelihood of any substantial advance in this direction. By using light of short wave-length, a promising field of research is at once opened up. An increase of resolution is obtained even with visible light if the violet or blue end of the spectrum is utilized, but the increase is much more definite if ultra-violet light is used, although the image is no longer a visual one.

The computation of microscopic objectives for use with ultra-violet light presents considerable difficulties, as only two substances sufficiently transparent to these radiations are available—quartz and fluorite. So long ago as 1860 Spencer in America used fluorite for this purpose, and at a much later date Boys in this country suggested the possibility of using fused quartz. In 1904 Kohler, of Jena, succeeded in computing objectives entirely of fused quartz, some earlier ones which were fluorite-quartz combinations being thereby superseded. Ultra-violet light, therefore, became available for microscopic work, but the practical difficulties in the use of the apparatus are so considerable, calling for almost more knowledge of physical than of microscopical methods, that it has been used by few.

The results obtained, particularly in biological work, are in many cases of great interest, as, in addition to the advantages already indicated, there is the further important point that organisms are dealt with and photographs obtained of them in the living state. The classic researches of Hartley showed that organic substances which are perfectly transparent to ordinary light have very definite absorption regions or bands in the ultra-violet, and that their absorption is, in many instances, so characteristic that it constitutes an accurate method of identification. To a considerable extent, this fact is of value when using ultra-violet in microscopy. Objects that show little or no structure by transmitted light are seen to be highly organized when examined by ultra-violet radiations, and the structure seen is in part dependent on the wave-length of the light used. Objects for examination by this method must be dealt with in the living state, or at least in such a manner that no change takes place in their constitution. It follows that none of the ordinary methods of mounting such things as micro-organisms, in which staining, hardening, fixing, drying, or heating is resorted to, can be employed. The method is, in fact, its own staining process, differentiation of structure depending on the difference of absorption in ultra-violet, and not on complex staining processes, which are in some cases causing appearances not associated with the organism itself. Further, apart from the alteration that may take place in the tissues themselves as the result of such processes, their employment in the method under consideration would render them opaque to the radiations used, and, therefore, useless for the purpose. The organisms or tissues are simply mounted in any suitable fluid, such as water, normal saline, Ringer's solution, etc., which is transparent to ultra-violet light and the photograph is taken at once. The result is an image that, whether it shows more or less than a stained preparation, is a representation of the object in the living state, and with greater resolution than can be obtained in the microscope by any other process.

Such a method is obviously one to be tried to its utmost whatever practical difficulties may be involved, and there is little doubt that in time it will be recognized as what it really is—the only great advance in microscopic technique for a generation. The apparatus as used by the present writer is in its essentials the same as that devised by Dr. Kohler (Fig. 1), although in many points of detail improvements have been devised. The quartz objectives are three in number, their equivalent focal lengths being 6 mm., 2.5 mm., and 1.7 mm., their effective numerical aperture being respectively 2.50, 1.7, and 0.7. It will at once be appreciated that in cases where the full aperture can be utilized the two higher powers are of much greater N.A. when used with light of 275 $\mu\mu$ wave-length than any objective available for use with ordinary light. These two are glycerine immersion combinations, the refractive index of the immersion fluid being 1.447.

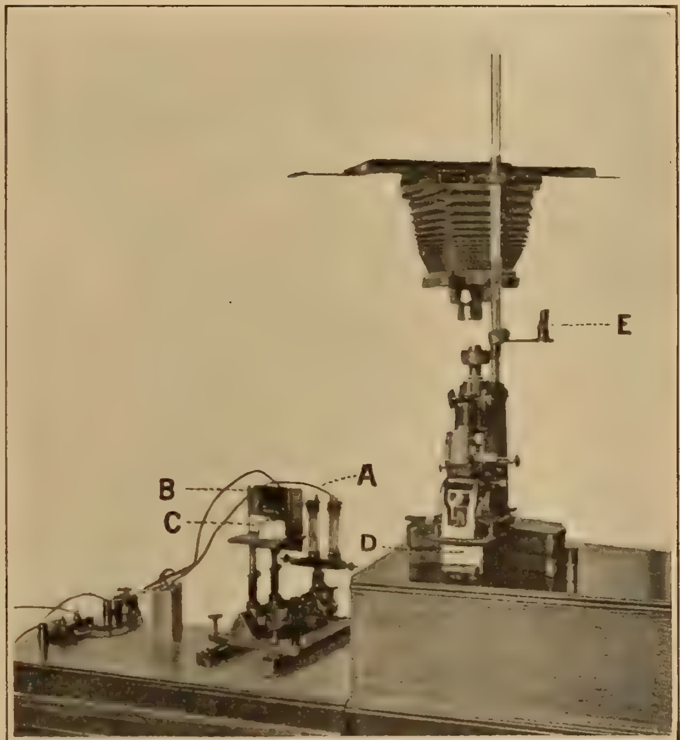
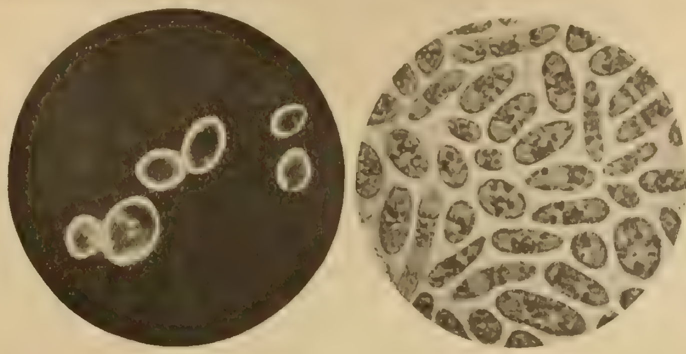


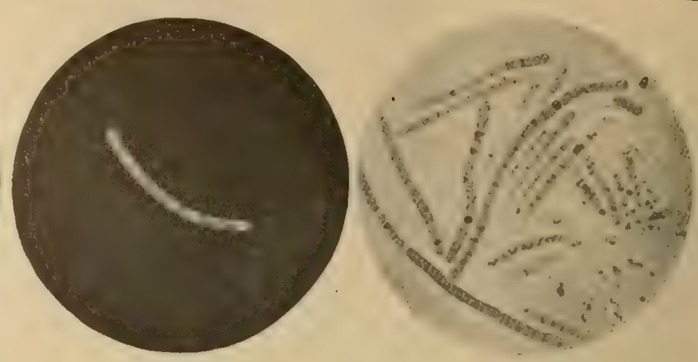
FIG. 1. APPARATUS FOR TAKING PHOTOMICROGRAPHS WITH ULTRA-VIOLET LIGHT

A, spark gap; B, quartz condensing lens; C, quartz prisms; D, box containing reflecting quartz prism; E, fluorescent ocular. The position of the other parts described will be evident to any microscopist

*Reproduced from *Nature* (London), Nov. 18, 1920.



FIGS. 2 AND 3. SACCHAROMYCES PASTORIANUS (YEAST) ×1200
Left dark ground illumination; *right,* ultra-violet light



FIGS. 4 AND 5. BACILLUS ANTHRACIS ×1000
Left, dark ground illumination; *right,* ultra-violet light

As these systems are not homogeneous, the cover glasses are optically worked fused quartz of uniform thickness.

The slides are also of fused quartz, fitted into a carrier of a special type, which ensures that the surface of the slide is a constant distance from the objective, a point that in practice is of considerable importance. The quartz oculars are five in number, and range from an initial magnification of 5 to 20, giving camera magnifications of from 200 to 3,600 diameters. The latter is a good deal too high for satisfactory results with most objects—in fact, it is doubtful, on theoretical grounds, whether such a magnification is justified. The quartz sub-stage condenser is made with a duplex top, so that a combination is available for each objective to ensure that a suitable cone of illumination is used in each case. This is used as a glycerine immersion system with the two high-power objectives, and as a dry system with the lowest one.

The source of light is produced by a high-tension discharge in air between metal electrodes, usually cadmium or magnesium, although other metals may be used if they produce a suitable line spectrum. There are obvious limitations in this respect, as the character of the spectrum emitted must be such that the principal lines in the ultra-violet region are sufficiently separated and of considerable intrinsic brilliancy. The spectrum of iron, for instance, is excluded, as, although it is rich in bright lines, these are so numerous and therefore so close together that the isolation of one line is impossible under the conditions realized in this method.

The spark is produced by means of an induction coil of special design giving a heavy discharge of relatively low potential, the equivalent sparkgap being about 5 cm. This is further reduced by placing a condenser immersed in oil in parallel with the spark-gap. The interrupter may be either an electrolytic one or a mercury break, the latter appearing to be more satisfactory. Special arrangements are made for accurately adjusting both the length of the spark and its position in relation to the optic axis of the microscope. The image of the spark is projected by means of a quartz lens, so that, after passing through a pair of quartz prisms of opposite rotation, an image of the spark in one wave-length is obtained approximately at the position of the iris diaphragm below the sub-stage condenser. To facilitate adjustment, a disk of uranium glass is placed at the latter position so that an image of the spark can be observed and focused as required, after which the uranium glass in its carrier is swung aside. The direction of the illuminating beam is at right angles to the optic axis of the microscope; it has, therefore, to be reflected by a right-angled quartz prism along the axis in the same way that the mirror operates in an ordinary microscope.

The preparation being placed on the stage, the light adjusted, and the condenser accurately focussed on the object, the actual focussing of the image has to be carried out. This is effected by means of a fluorescent searcher eye-piece which is mounted above the quartz ocular, and by the use of which an image is seen on a fluorescent screen and focussed by means of an auxiliary magnifier. This operation is one of considerable difficulty, and only after long practice can success be assured. Its difficulty varies, too, according to the wave-length used; in some cases the fluorescent image is bright, but in others it is much more difficult to see. Some objects themselves fluoresce, with the result that a sharp visual image cannot be obtained. The method now largely adopted by the writer is to observe the object by monochromatic light as emitted by a quartz mercury vapor lamp. This illuminant has bright lines in the violet, blue, green, and orange regions, and by means of screens any one of these can be transmitted.

The image having been focussed visually in one of these lines, the fine adjustment of the microscope is moved by a predetermined amount so that the image is in focus for any desired wave-length in the ultra-violet. This method is quite practicable provided that the fine adjustment of the microscope is of sufficient accuracy (the searcher eye-piece is not used in this case except to confirm the accuracy of the process). The focussing having been performed, the searcher eye-piece is removed, the camera placed in position, and the exposure made. The image is projected for a certain distance, so that it is in focus at the plane of the plate with a known length of camera. The exposures required are as short as two seconds under favorable conditions, even at high magnifications.

There was considerable difficulty in obtaining a suitable photographic plate, as one was required of fine grain and with the smallest possible quantity of gelatine on its surface. Gelatine is itself opaque to ultra-violet light, so that the photographic action is confined to the surface of the gelatine, little or no penetration in depth taking place as with ordinary light. The result is that plates must be prepared with the smallest possible quantity of gelatine, but with the maximum quantity of sensitive silver salts that the gelatine can hold together. Such a plate has been prepared by the Kodak Co., and has proved satisfactory. Plates as prepared by Schumann for work in the far ultra-violet have also been experimented with, but for various reasons have not proved so satisfactory. The resulting negatives are at first glance somewhat disappointing if judged by ordinary photographic standards. They are always thin and lacking in violent contrasts, owing to the superficial action of the light, but the detail and fineness of lines due to the shorter wave-lengths used are evident to anyone having any knowledge of photomicrography. Whether the utmost resolution that theory demands can be achieved is at present unproved because of the difficulty of finding an object that can be regarded as a satisfactory test.

The accompanying illustrations give some idea of the comparative results obtained with living organisms. Figs. 2 and 4 are illuminated by a concentric dark-ground illuminator, the most satisfactory method available for observing living organisms by ordinary light, and Figs. 3 and 5 by a solid cone of ultra-violet light.

Artificial Cells*

Remarkable Imitation of Natural Cells

By A. L. Herrera

Director of the Bureau of Biological Research of Mexico

It is a well-known fact that numerous attempts have been made to reproduce the structure of the natural cell, especially by Bütschli, Traude, Lebuc, and Herrera. Professor Herrera gives here the results of his latest researches, which have been remarkably successful, along these lines.

It must be borne in mind, of course, that the structures of natural cells obtained by treatment according to the classic histological methods, can hardly be said to correspond closely with the aspect of the same cells while living. When the endeavor has been made to indicate the structure of natural cells by means of precipitates from various solutions, the investigator has too often taken as his model the histological aspect, and not the living appearance of the cell in question. Because of this, considerable caution must be maintained in drawing definite conclusions from such experiments.—Preliminary note by the Editor of *La Nature.*

THE admirable researches made by Gautier and Clausmann with respect to the biological importance and the general occurrence of fluorine in organic creatures are now well known, as are also the studies made by Schultz and Boudard concerning the presence of silica in organic tissues together with the physiological rôle and therapeutic application thereof. These two elements have been unjustly neglected for a great many years, but modern research has shed light upon their importance in the phenomena of life. One fact of especial significance is prominent through the researches with regard to plasmodeny, which I have been conducting since 1897, and which have led me to devote special attention to the fluoro-silicate. This fact is that the imitations of cells and tissues obtained by means of the silico-carbonate of calcium although possessing a great morphological resemblance to natural elements are attacked and dissolved by the histological fixators, all of which are acid—a circumstance which sets them greatly apart from living models. Nevertheless, I have sought to discover artificial structures capable of presenting a like degree of resistance to acid. An earlier observation incited me to study the remarkable imitation produced upon glass by the vapors of hydro-fluoric acid—structures which reproduce those of micro-organisms found in stagnant water, but which are much harder than the latter and which exhibit much difficulty in acquiring histological coloration.

In my first experiment I repeated the technique employed by Harting (vide C.R. *de l'Acad. d. Sc.*, May 19, 1919). In an 18 cm. crystallizing dish I placed some colloidal silica having a density of 1,030 together with two soluble salts, calcium chloride and potassium fluoride. Through slow diffusion and incomplete crystallization I secured the formation of really remarkable imitations of amoeba and of organic cells. Finally, by means of a gradual improvement in the conditions of diffusion I succeeded in producing truly wonderful facsimiles of histological elements. The specific technique employed consisted in compressing between sheets of glass two solutions, one of potassium silicate having a density of 1,100 and containing traces of potassium bifluoride and the other of calcium fluoride with a density of 1,320. The solution of the silicate should contain as small a quantity of potash as possible; it is prepared by dissolving freshly prepared gelatinous silica in 750 cubic centimeters of water to which have been added 10 drachms of caustic potash. As high a temperature as possible is then applied in a vulcanizer.

In the last experiment a drop of silicate was compressed beneath a sheet of glass by means of a weight of 22 kg., while the drop of calcium chloride was compressed by a weight of 5 kg. beneath the contiguous sheets. The sheets of glass are then covered with a bell glass under which are introduced moistened cloths; the edge of the bell-glass is smeared with plaster of paris in order to prevent the drying of the solution. The object of the compression is to retard the diffusion of the liquid, thus imitating those infiltrations which produce agates. Twenty-four hours later they are washed and examined under the microscope then fixed, colored, and mounted in balsam as is done in the case of ordinary sections of tissues. Care must be taken to employ Kuhne's blue and mordants, since the structures are still too hard and too slightly permeable.

The waves of diffusion produce periodical precipitates and the exhaustion of the calcium chloride solution occasions the gradual transformation of the waves into smaller and smaller segments, which reproduce the form and structures of cells with surprising fidelity, as can be seen by the accompanying sketches and microphotographs.

In preparation 3,804, of May 17, 1920, there was observed a complete colony of cells having a membrane, a spongy cytoplasm, or spongioplasm, a nucleary membrane, a nucleus, a nucleole and chromatic filaments. The pseudo-cells earlier observed by Traube, Leduc, myself, and others, are far inferior to these truly magnificent elements in which the enormous nucleus, when highly magnified, shows the finely granulated aspect of the nucleus found in true cells as well as other well-known details.

And an even more striking feature is the tendency to division exhibited by all these cells, as can readily be seen at certain points in the reproduction of this same preparation, as well as in others prepared for the Academy of Sciences.

FIG. 1. MICROPHOTOGRAPH OF A PREPARATION MADE BY PROFESSOR HERRERA

The mitosic figures are still vague and incomplete, but two stars (asters adossi) backed up against each other in the poles of the ovoids and the filaments between them can readily be distinguished. Asters are often found in the points of an elongated granular tube. By compressing the

*Translated for the *Scientific American Monthly* from *La Nature* (Paris), July 31, 1920.

sheets of glass under a pressure of 60 kg. I succeeded in obtaining colonies of cells undergoing the process of division, taking the blue stain and revealing all the passages between the cells with the nucleus and the protoplasm in a state of repose, as well as those showing the division of the nucleus without the division of the protoplasm, with an ulterior division of the latter and the complete separation of the daughter-cells. One of these preparations was sent to the French Academy of Sciences, and the other to Dr. MacDougal of the Desert Laboratory at Tucson, Arizona.

But what explanation can be offered for the occurrence of these results and how shall we interpret them? This question is not very easy to answer and is much less interesting than the facts themselves.

FIG. 2. CELLULAR APPEARANCE OF PREPARATION NO. 3804 OBTAINED BY SUBJECTING POTASSIUM SILICATE AND CALCIUM CHLORIDE TO PRESSURE

FIG. 3. MAGNIFIED VIEW OF A PORTION OF THE PREPARATION SHOWN ABOVE

At 2 is shown the reticulated structure of a natural cell, after Schäfer, showing, from periphery to center the membrane, protoplasm, nucleus and nucleole

When macroscopic crystals of the double chloride of calcium and potassium are placed in a bath of potassium silicate, it is observed that each crystal encloses a residue of the calcium chloride solution; this produces very fine precipitation, membranes forming a sort of protoplasmic emulsion. It is probable that the same effect is likewise produced in this instance, but upon a microscopic scale and that we obtain a perfect reproduction of the structure of the protoplasm and the nucleus of which Bütschli speaks. The cause of the segmentation, it is to be presumed lies in the osmotic swelling of invisible alveolæ whose saline enchylema must be supposed to have a great affinity for the water of the external milieu. The hardening of the structure is due to a sort of intensive plasmolysis or dehydration which prevents the later development of the cells and which I have sought, by the condition of my experiments, to retard as much as possible.

A hypothesis at once suggests itself as the result of our researches and reflections. I refrain from calling it a certainty to the effect that life itself may have had a similar origin in the form of slow infiltrations of salts in the silica containing fluorides. A large number of organic compounds of fluorine, of silica, and even of fluoro-silicates, are known to us, and it is possible that upon a mineral skeleton natural forces—heat, sunlight, etc.—have produced protobias capable of living by means of antotrophic processes. Whatever may be thought of this theory, however, the fact reported above, of the production of cells, not only complete in all their parts, but actually undergoing division is both entirely new and profoundly interesting.

NEW FACTS ABOUT VITAMINES

MUCH as we have learned in recent years about those all important though minute constituents of our food, the vitamines, the field of research is by no means exhausted and still attracts many investigations. Some recent results of their studies have appeared lately in various places. Among these are those of M. Auguste Lumiére, who has been trying to find out whether these bodies are as essential to the lives of plants as to those of men and animals. He comes to the conclusion that this is not the case. He bases his views upon the fact that microbes can be readily cultivated in mediums of strictly mineral composition which exhibit no traces of organic matter. According to another investigator, maize is capable of attaining complete development in a liquid containing 15 simple substances without any organic matter whatever. Lumiére made certain experiments of a similar nature with beer yeast, which is particularly rich in vitamines, for which reason it rapidly effects a cure in pigeons suffering from malnutrition. He found that when the yeast was heated to a temperature of 135° C. for one hour, it had lost all its curative virtues, its vitamines seeming to be entirely destroyed. Yet fungi were found to grow readily in a broth made of this dead yeast. Furthermore, he found that it was possible to isolate the vitaminic principles of the yeast and add them to various culture mediums, without apparently improving the species grown in these. He, therefore, finds that plants do not require the presence of vitamines for their development.

Another experimenter whose work is reported in the *Presse Médicale* believes that he has obtained proofs that the disease of rickets which so often afflicts under-nourished children, is really due to a lack of vitamines, particularly of the lipo-soluble vitamine A. By experiments upon dogs he demonstrated that a diet which produces rickets in the animals ceases to do so if foods rich in vitamines be added, among which he mentions especially butter, unskimmed milk, cottonseed oil and cod liver oil. He finds fresh support for his views in the fact that rickets is a very rare disease in the Hebrides, in spite of the many hardships and privations to which the inhabitants of these islands are exposed. The population lives almost entirely upon fish, oatmeal and eggs, being particularly fond of fish livers, which are known to be especially rich in lipo-soluble vitamines.

It is interesting to find that the popular estimation of cod liver oil as a waste repairing food is thus justified and explained by modern research. Apropos of various facts it is worth noting that while butter and cream and cod liver oil are extremely rich in vitamines, ordinary fat is much less so, especially when it is white in color. Lard, for example, contains practically no vitamine, whereas the yellow fat of grass-fed cattle contains a considerable percentage.

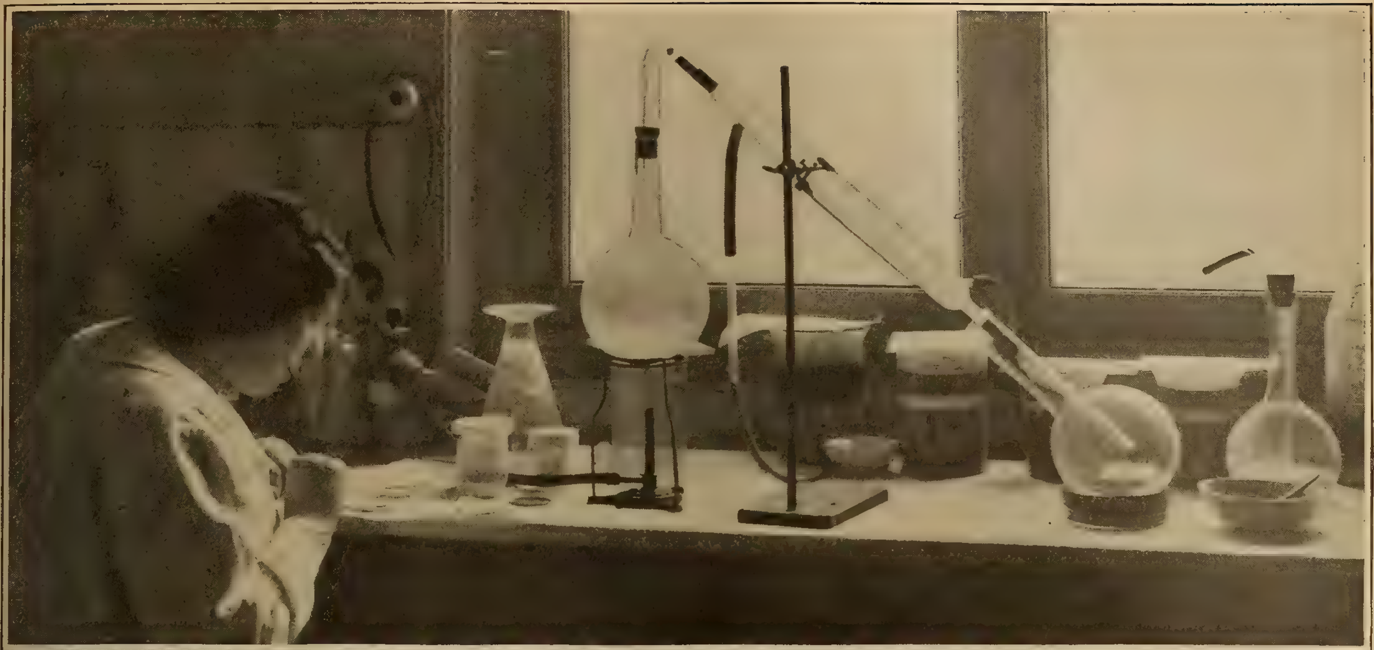


FIG. 1. MADAME CURIE WATCHING THE DISTILLING APPARATUS IN WHICH URANIUM IS UNDERGOING PURIFICATION

The Radium Institute in Paris

The Scientific Equipment of Madame Curie's New Radium Pavilion

By T. A. Marchmay

ALTHOUGH the building which houses it is but a few years old, having been finished at about the time the war was declared, the French Radium Institute now ranks as one of the best equipped in the world, among similar foundations. The work done comprises two branches—the study of the scientific properties and relationships of radium, on the one hand, and its medical applications upon the other. At the head of the former department are Madame Curie and Professor Debierne, while the director of the latter, which forms an annex of the Pasteur Institute, is Dr. Regaud.

The first department is housed in that portion of the building known as the Curie Pavilion and within its walls are carried on by Madame Curie and her assistants those profound experiments which have for their object the widening of the boundaries of our knowledge concerning this most marvelous of elements as well as the practical application of the information we already possess with regard to it. Here, for example, we may see operators at work standardizing the small but infinitely precious radio-active tubes, each of which contains a certain amount of miracle working substance. The method employed in this standardization is known as the piezo-electric quartz method which is described below. These tubes are delivered to physicians and before their dispatch it is necessary that the absolute value of the amount of radium contained in each tube shall be determined. In Fig. 3 the radium tube is seen upon the condenser at the right of the photograph.

FIG. 2. HEATING A SOLUTION OF URANIUM IN A WATER BATH

When thin lamellæ of quartz or tourmaline are subjected to pressure they develop electricity, known as piezo-electricity. (It. *piezo* = pressure.) This pressure electricity is produced in very minute quantities, yet by means of a very ingenious apparatus which was devised by J. J. Thomson, it has been found possible to employ it to operate a highly sensitive electrometer.

One of the most important of the processes carried out in the chemical laboratory consists of the lengthy series of delicate operations involved in the repeated fractionization and crystallization required in the preparation of the various radio-active salts, *i.e.*, those of radium, polonium, actinium, uranium, thorium, etc. One of our views (Fig. 1) shows Madame Curie herself watching the distilling apparatus in which the nitrate of uranium is undergoing purification; the famous chemist is shown inserting a few milligrams of polonium between two disks of metal. In another view (Fig. 2) she is seen heating a solution of uranium in a water bath.

PREPARATION OF PURE RADIUM SALTS

To obtain pure radium salts it is necessary to subject first the ore and then the first crude salts obtained to an extremely laborious, complicated, tedious process—and it is this fact to which the enormous cost of the pure salts is largely to be ascribed. Luckily, however, they are extremely potent even in minute amounts.

The finely crushed ore is first fused with carbonate of

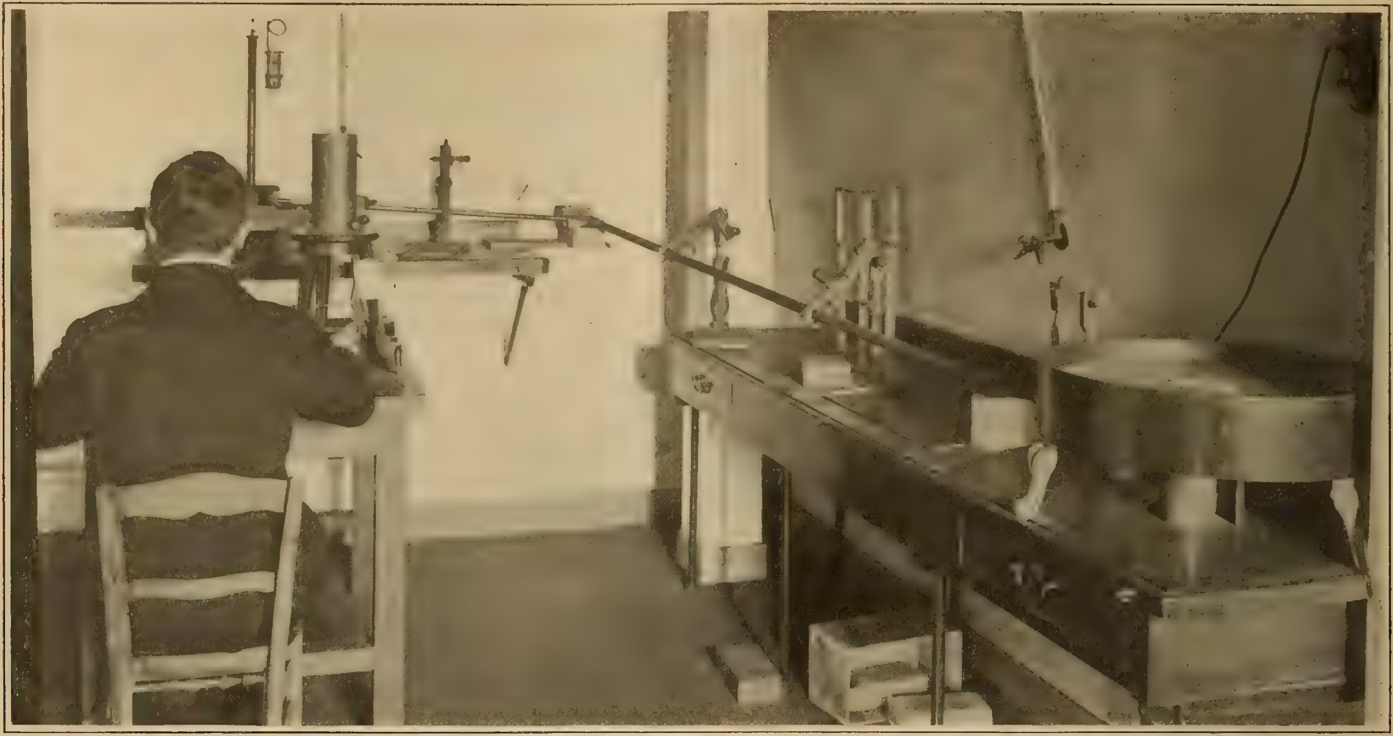


FIG. 3. STANDARDIZING RADIOACTIVE TUBES BY THE PIEZO-ELECTRIC QUARTZ METHOD

soda, then cooled and broken up, after which it is washed in water nearly at the boiling point to which a little sulphuric acid has been added. The fluid portion now contains all the uranium present, while the residue is treated with caustic soda to remove the acid; this process also removes the lead, calcium, and aluminum, leaving the radium ore reduced to a smaller bulk. This new residue is washed and hydrochloric acid added which dissolves any actinium or polonium contained, leaving the barium which contains the radium. The actinium and polonium are precipitated by sulphuretted hydrogen and collected, since they are likewise of value. To the residue sodium carbonate is now added, and later hydrochloric acid, which forms chlorides of the barium and the radium; these chlorides are then transformed into sulphates. The object of all this is to reduce the bulk and the process is repeated again and again until a ton of ore has been refined down to about 38 pounds. This bulk, which is already strongly radioactive, is now subjected to a series of practical precipitations by which means it is crystallized until finally a comparatively pure specimen of *radium chloride* is obtained. This chloride must pass through another long and tedious process before "commercially pure" radium bromide is obtained.

It is of interest here to quote Mme. Curie's own words in regard to the later stages of the process of purification. In her *Traité de Radio Activités* she says: "The process which I have employed for extracting pure radium chloride from radiferous barium chloride consists in fractional crystallization, first in pure water and then in very dilute hydrochloric acid. By this means I take advantage of the different solubility of the two chlorides, that of radium being the more soluble. I first make a saturated solution of the chloride in distilled water at the boiling point. This solution is then crystallized by being allowed to cool in a covered evaporating dish at the bottom of which fine adhering crystals form, so that the supernatant solution can be easily decanted. If a sample of this solution be evaporated to dryness the chloride obtained is found to be only one-fifth as active as the crystals in the basin. Thus the chloride has been divided into an active portion A and a less active portion B. The same process is repeated with each of these, two new portions—one more active than the other—being obtained from each. When the crystallization is ended the *least active fraction of the A chloride* and the *most active* fraction of the B cloride are mixed—these two being about equally active. By this means 3 portions are obtained which are submitted to the same treatment. The operation is repeated until the most soluble portion is so poor in radioactive matter that it can be eliminated. In the same way when a suitable amount of the residue which is the richest in radium is obtained that is also eliminated."

In brief therefore these elaborate operations result in obtaining a chloride rich in radium on the one hand and a nearly inactive product on the other. The treatment is continued until the crystals on the top represent pure radium chloride.

Perhaps the most remarkable room in the Radium Institute is that devoted to the extraction of the radium emanation. The radium compounds are kept in a safe, the sides of which are covered with sheets of lead. The radium salts are placed in glass vials provided with curved tubes connected with a mercury manometer. Some idea of the value of these substances is shown by the fact that $100,000 worth of one of them can be held in the hollow of the hand.

The radium emanation is generally preserved inside of flasks containing liquid air and for this reason a necessary part of the equipment is a machine for liquefying air (Fig. 5).

LUMINOSITY OF RADIUM COMPOUNDS

All radium compounds are spontaneously luminous. The salts lose much of this luminosity in damp air but recover it on drying. Very active preparations of actinium are also luminous and Becquerel has observed that crystals of uranium nitrate are spontaneously though feebly luminous.

In many experiments in radioactivity it is necessary to measure variations in activity of a substance over long intervals of time. This is done usually by an electroscope but since the sensitiveness of these and other measuring instruments is subject to alterations from various causes it is very desirable to have some simple means of correction. Such correction is made most easily by the use of radioactive standards.

IONIZATION STANDARDS

The most convenient substance to employ as a standard of ionization is the black oxide of uranium. This is ground to a fine powder and mixed with an organic liquid, e.g., chloroform or ether. The mixture is then poured over a plate of aluminum or copper. The liquid soon evaporates, leaving a

uniform, closely adherent film of uranium oxide. Practically all the ionization produced by these films is due to the alpha rays. The ionization current due to the active substance being observed is directly compared with that view to the uranium standard. The ratio of these two currents is independent of any variations in the sensibility of the measuring instrument.

POLONIUM

Polonium was discovered by Madame Curie and named in honor of Poland, her native land. It was the first active substance separated by her from uranium minerals, a ton of which had been presented to her by the Austrian government in the form of residues from the Joachimsthal mine in Bohemia. Madame Curie has succeeded in concentrating polonium by various methods and in obtaining preparations having a high degree of activity. These preparations were, some years ago, placed on the market in the form of films adhering to a polished disk or rod of bismuth. More recently Madame Curie has made further attempts to isolate polonium, obtaining preparations which are very highly active. She has also determined some of the lines of its spectrum. Polonium is one of the series of products resulting from the transformation of radium. Like the latter it is found in pitchblend but in amounts only 1/5000 part as great as the radium, which is itself, as we have shown, found in very small quantities. Convenient sources of polonium, however, are preparations of radio-lead in solutions of which polonium is produced at a constant rate, and from which it can be separated merely by tracing a bismuth plate in the solution. It has the peculiarity of emitting only alpha rays, the strongest line in the spectrum is designated as 4170.

FIG. 4. MADAME CURIE'S LECTURE ROOM

One milligram of polonium in the pure state has been calculated to emit as many alpha particles as 5 grams of radium itself. Thus an almost invisible amount of pure polonium will make phosphorescent screens brought near it brilliantly luminous. There is strong reason to believe that after the emission of a helium atom polonium turns into lead and it is believed that the transformations of the uranium radium series with lead as the final product.

URANIUM

Uranium, on the other hand, is highly complex; it has the highest atomic weight of any known element, namely, 238.5; it is usually separated from uraninite where it is always associated with ionium, radium, and actinium. The transformations which take place are from uranium to uranium X, to ionium, to radium and the series of products of the latter.

THE PASTEUR PAVILION

The Pasteur Pavilion, which as stated above, is an annex of the Pasteur Institute, is devoted to the treatment of cancer and tumors by means of radioactive substances and X-rays. In one of our pictures is seen a patient suffering with a facial tumor, undergoing treatment by means of X-rays. The patient's head is at a distance of about 20 cm. from the Coolidge tube. This apparatus is surrounded by a protective jacket. The physician, who is sheltered from the X-rays by means of a lead partition, observes the application through a window.

One hundred and twenty thousand volts are available for the radiotherapeutic treatment.

Preparing the Radium Emanation for Therapeutic Uses.—For curative purposes the emanation is confined in small glass

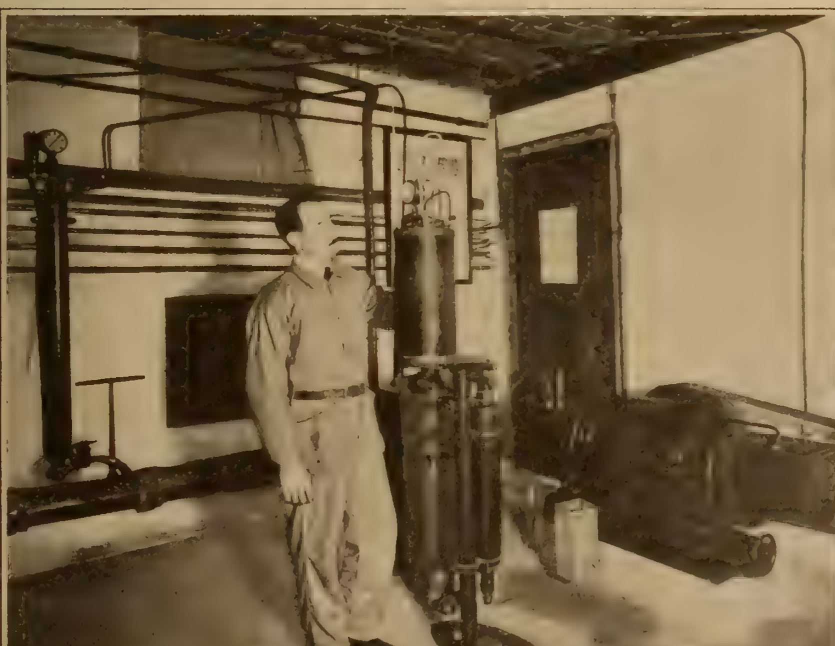
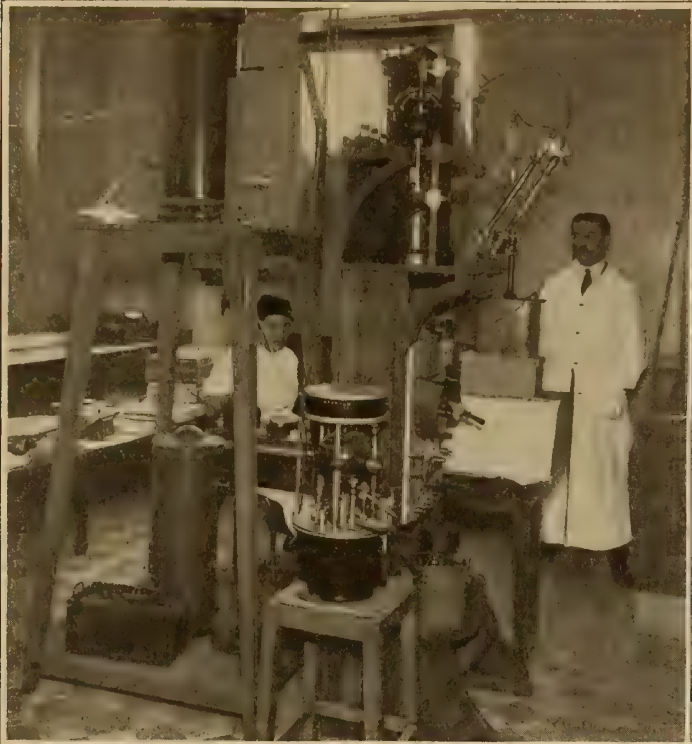
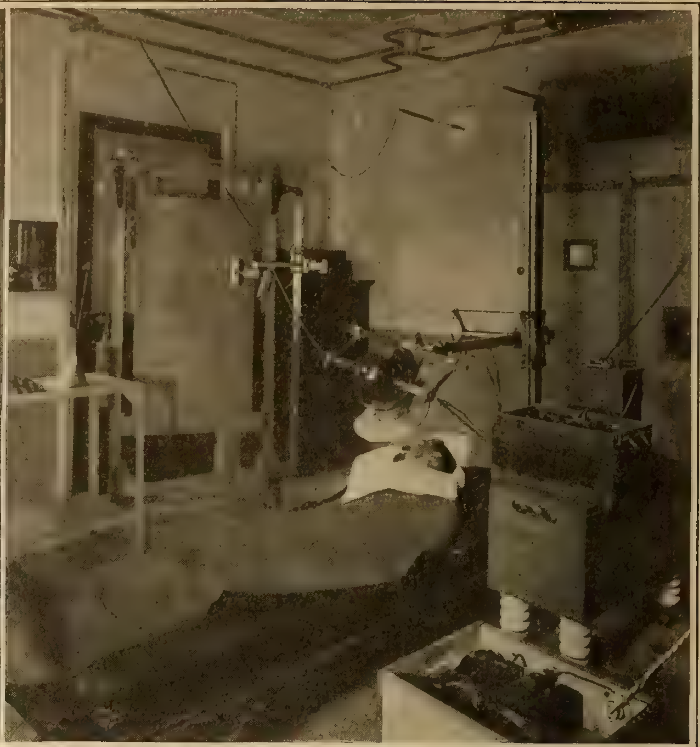


FIG. 5. THE MACHINE FOR LIQUEFYING AIR

FIG. 6. A POWERFUL ELECTRO-MAGNET



APPARATUS EMPLOYED IN THE PASTEUR PAVILION FOR THE RADIO TREATMENT OF CANCEROUS TUMORS



PATIENT RECEIVING RADIO TREATMENT. NOTE THE LEAD SCREEN BEHIND HIM

tubes of two general sizes; the larger are about 0.6 mm. in diameter and 10 to 15 mm. long, and when first made contain from 100 to 250 milicuries of the emanation and sometimes even as much as 400 mc. The smaller tubes are about 0.3 mm. in diameter and 3 mm. long; each of these contains from 1 to 4 mc. of the emanation.

The "dose" of radiation employed for curative purposes is specified in mc.-hours per square centimeter of the surface treated, the total amount of emanation used and the total area also being stated. A very recent application of this treatment in dental practice is by the use of bare tubes. Writing in *Radium* (New York), Gioacchino Failla, Ph.D., says explicitly, "during the last two years we have treated a great many patients by inserting tiny emanation tubes into the growth by means of a steel trocar and *leaving them to decay in situ*. We had previously used steel needles with a tube of emanation at the end according to the method of Dr. Stevenson of Dublin, with considerable success in certain cases. The new method, however, proved to be far more effective and of wider applicability."

CURATIVE USES OF RADIUM SALTS AND RADIUM EMANATION

The present extensive use of preparations of radium by the medical profession for therapeutic purposes is largely due to the brilliant researches of the English physician, Dr. Wickham —so much so that a leading authority has declared that in the medical use of radium there are two epochs—"Before Wickham" and "After Wickham." The various methods of application are chiefly comprised under 5 heads: A. *Long applications.* The apparatus used for these exerts a mild effect and can be employed for long periods, even for infants. B. *Very brief applications.* For these very powerful instruments with large surfaces, and unscreened, are used. The time of exposure is from half a minute to one minute. C. *Fractional doses.* The action of the radium rays on organic tissues depends on the manner in which a given amount of energy is applied. The total amount sometimes yields better results when divided into fractional doses. D. *Applications at intervals.* Variable effects are produced by applications at varying intervals. It is necessary for these to be carefully observed and regulated by the physician in charge of the case. E. *Internal applications.* Radium preparations enclosed in tubes can be introduced internally in treating diseased portions of the body. They are sometimes covered only with rubber, but at others are covered with lead or aluminum screens.

Experiments on animals have shown that radium has a marked effect on the nervous system, especially the central nervous system. Thus, when a tube containing 1 centigram of radium was placed beneath the skin of a mouse one month old, exactly over the spinal column and part of the skull, the little creature developed paralysis in 3 hours' time, was seized with convulsions at the end of 7 or 8 hours and died in from 12 to 18 hours. Mice a year old live from 6 to 10 days under such conditions. Such experiments seem cruel enough at first glance, but they have pointed the way to the relief of severe cases of neuritis and facial neuralgia.

RADIUM EMANATIONS

In the destruction of disease germs the emanation has been found more useful than the direct rays—killing or checking the growth of anthrax, typhoid and diphtheria germs. Of especial interest is the proved value of radium in the treatment of rheumatism, that too common scourge of the old. Dr. Guyenot says concerning this: "Uric acid circulates in the blood in the form of urate of soda, of which there are two isomeric forms differing from each other by their respective solubility in the blood plasma. The soluble salt is converted into an insoluble form," urate of soda. Radium breaks up this compound. Dr. Guyenot has succeeded in effecting entire cures of severe cases of rheumatism by radium.

SKIN DISEASES, CANCERS, TUMORS, ETC.

The most extensive therapeutic applications of radium are for affections of the skin and for abnormal growths. Its healing power is directly connected with the fact that it possesses a remarkable selective power with reference to its action upon cells. As we have seen, it was the *young* mouse which was most seriously and rapidly affected. Similarly it is *young* and rapidly growing cells in an adult body upon which it makes its selective attack. Since such cells are formed in tumors and cancerous growths, it at once becomes evident why the radium destroys *these* abnormal tissues before acting upon normal tissues.

Is Heliodor a New Gem?*

An Instrument for Examining the Luminescence of Precious Stones

SOME little time before the outbreak of the war the announcement was made that a very brilliant new gem of a dazzling golden luster shot with green, *i.e.*, changing into green under artificial light, had been discovered in German Southwest Africa. Specimens of this magnificent new gem were presented to the Emperor and Empress of Germany in artistic settings designed by the distinguished painter, Lucan von Cranach. The happy thought occurred to the latter of bestowing the name heliodor, *i.e.*, the golden sun, upon the new stone. Dr. Alfred Eppler writing in *Die Umshau* while acknowledging von Cranach's gifts as an artist, does not hesitate to say that he had practically no technical knowledge of gems. He, thereupon, raises the question as to whether heliodor really is a new gem and, incidentally, discusses entertainingly the qualities that properly constitute gems, *i.e.*, precious and semi-precious stones, and the scientific and other tests proper to determine these qualities. He remarks:

The stones were cut in Idar near where they were found and the gem cutters there said at once that this was by no means an unknown new stone but a seldom observed variety of the beryl, adding, that this brilliant golden color is oftener found among the aquamarines of Brazil and Madagascar. Previous to its exploitation in newspapers, however, because of the gift to the Kaiser it was not highly valued in the jewelry trade. The German company, which had made the gift apparently made a shrewd use of this exploitation, stimulating the public curiosity but refusing to throw the stone upon the market. This naturally irritated the Idar gem dealers. They hunted up the yellow beryl which they had previously laid aside as having little commercial value in spite of their beauty, sent them to the cutters and sold them under the new name heliodor. The colonial company which had presented the original "heliodor" was much disgruntled by this action, but since the name had not been protected as a trade-mark the Idar jewelers were as free to sell their greenish-yellow beryls from Brazil and Madagascar under this name as the German Colonial Company theirs from German Southwest Africa. The Colonial Company thereupon took steps to prevent the Idar dealers from sharing in the enhanced price of the yellow beryl, publishing the following statement:

"*Heliodor.*—The article which appeared in No. 19 of the '*Woche*' and in the trade paper '*Die Goldschmiedekunst*' of June 7, 1913, has been the occasion of the receipt by us of numerous inquiries from gem dealers and jewelers concerning this stone; furthermore, similar material also designated heliodor has been offered to us and to other interested parties. These latter stones of different origin from our own failed to meet the test to which they were subjected. The uncut gems coming from our mines are few in number, and have not been given by us to the trade. We, therefore, beg all interested persons to be extremely cautious in their own interest with respect to the purchase of all stones purporting to be true 'heliodor.' Signed Deutsche Kolonialgesellschaft für Südwestafrika, Berlin W. 35, Am. Karlsbad 10."

Upon this announcement a number of jewelers returned the Idar stones to the consignors, and the matter soon threatened to form a very pretty legal dispute. Dr. Eppler, being a well-known gem expert, was approached from various quarters among gem dealers and jewelers with the request for an authoritative pronouncement concerning the truth of the matter. He very wisely determined to settle the matter if possible out of court by scientific methods, knowing that the sort of dispute in question does either party less good than the damage done to both the domestic and foreign trade. He, therefore, determined to endeavor to obtain specimens of their heliodor from the Colonial Company in order to subject them to a searching comparison with the Idar stones.

He says: I readily obtained the desired specimen of Brazilian and Madagascar stones from Idar, but was not successful in getting samples of their heliodor from the Colonial Company, the excuse being that they had none on hand, but that some stones were on their way from Africa.

Some time later I had the opportunity, however, of seeing some of the heliodor belonging to the Colonial Company, since in the exposition of the Deutschen Werkbundes, held in Cologne in 1914, the heliodor jewels belonging to the Imperial couple were exhibited, with special arrangements to show the change of color by artificial light .... skilfully disposed electric lamps reveal that by such artificial light the play of green in the stones was somewhat more marked than in daylight. But in spite of repeated visits to the exhibit I was unable to perceive an actual change of color like that seen in Alexandrite, in spite of the fact that I have an uncommonly good eye for shades of color; so far as I could observe there was merely such an alteration of color as is commonly seen by artificial light in amethysts, many sapphires and other stones.

During my visits to the Exposition I was fortunate enough to meet Professor van Cranach in person, and after a good deal of trouble I finally succeeded in obtaining from him the loan of a few specimens of uncut heliodor, including the remainder of the crystal from which the stone of the Kaiser's scarfpin was cut. He lent me, for the purpose of scientific investigation, six pieces of crystal, the biggest weighing 43 3/64 carats and the smallest 7 47/64 carats. Unfortunately I was not able to obtain a cut stone.

Chemical investigation made by experts at the Technological Institute of the University of Berlin led them to conclude that heliodor belongs to the beryls. Its yellow color appears to be connected with its content of iron (0.55 per cent of iron oxide). The signed report sent me by these experts contains the following statement: "Upon the basis of these results we hold this mineral to be a new variety of emerald." This opinion is entirely incomprehensible to me and probably to any other authority on precious stones. The emerald is, indeed, also a beryl, but it owes its distinction from other beryls to its small content (cc. 0.3 per cent) of chrome-oxide; thus it might be termed chrome-beryl just as we speak of caesium-beryl, whereas, under the same system of nomenclature heliodor would be called iron-beryl, consequently, heliodor is no more nearly related to the emerald than is any other beryl.

Hauser and Herzfeld (the chemists referred to) listed the following features as characteristic marks in similar forms of beryl:

1. A plainly perceptible bluish phosphorescence under the influence of cathode rays.
2. A change of color from yellowish green into dull gray under longer exposure to the cathode rays.
3. The mineral is opalescent and exhibits a clearly perceptible though faint green fluorescence. Under artificial light the greenish tint becomes stronger.
4. A feeble radio activity probably connected with its content of uranium.

This communication lay before me at the time when I received from Professor v. Cranach specimens of heliodor for a further investigation. Since I was obliged to give him an express and positive promise that under no conditions would the stones be allowed to receive the slightest injury, I was not able to determine the density through the examination of

*Abstracted for the *Scientific American Monthly* from an article by Dr. Alfred Eppler in *Die Umshau* (Frankfurt a M.) for Aug. 21, 1920.

a piece of the pure mineral, but was obliged to make my estimate from the entire stones including impurities, flaws, etc. Under these conditions the best calculation I could make gave the figures 2.683, whereas, the density of beryl varies between 2.67 and 2.76. The refraction of light also (exponents of refraction) of beryl, also coincide very closely with that found for the heliodor. As respects the *characteristic color* I observed that the six crystals of heliodor lent me by v. Cranach differ greatly in tint; as a matter of fact there was a greater difference between these specimens than between them and the greenish-yellow beryls from Brazil and Madagascar, employed for comparison. When the latter were mingled with the African stones no one could tell them apart merely by the variation of the color. In order to test the stones also with respect to their luminescence I communicated with the chemist Bernhard Jost in Duisburg and conducted my further investigations together with him. This expert has at his disposal a considerable number of preparations of radium, ionium, actinium, and polonium. To conduct our tests he made use of a capsule containing 125 mg. of the purest radium bromide. Herr Jost is a well-known technologist in the domain of the experimental application of various forms of radiation. I had already some time previously tested together with him a tube invented by Professor Riedl of Vienna, for the investigation of luminescent phenomena in precious stones and kindly lent to me by him.

AN INSTRUMENT FOR EXAMINING LUMINESCENCE IN PRECIOUS STONES

This Riedl tube was of the utmost service to us in the investigation of heliodor and of the beryls of light color from Brazil and Madagascar. It enabled us to examine the stones, both with X-rays and with cathode rays. In my presence, Jost subjected all the stones to both sorts of rays, and this was usually done in such a manner that the African stones and those from Brazil and Madagascar were exposed to the radiation at the same time.

We observed that under the X-ray neither of the two kinds of stones was luminescent in a vacuum, while under the cathode rays, on the contrary, the stones from Southwest Africa shone with a magnificent luminescence while the beryls of light color from Brazil remained unaltered, failing to exhibit the phenomenon of luminescence. But it is a significant fact that the six specimens of heliodor from Southwest Africa also varied among themselves, the phosphorescence of some of them being violet blue, that of others rose color and of still others reddish yellow. It follows from these results that the heliodor from Southwest Africa can be readily distinguished from the beryls of the same color found in Brazil and Madagascar by means of the cathode rays in a vacuum or in a highly rarefied atmosphere. We have at present no information concerning the behavior of the beryls of similr color found in North America. An attempt to record the heliodor radiation upon a photographic plate produced no results after an exposure of twenty-four hours. We next exposed to the radiation given forth from 125 mg. of radium bromide, the specimens of heliodor obtained from v. Cranach, together with two from Brazil, two from Madagascar and blue beryl from Brazil, with the result that the blue beryl exhibited the strongest luminescence, the two greenish-yellow beryls from Brazil exhibiting the next degree of brilliance while the luminescence of the heliodor from Southwest Africa was fainter and that of the two beryls from Madagascar was faintest of all.

WHAT CONSTITUTES A PRECIOUS STONE?

Before we discuss the question as to whether the difference in luminescence is sufficient to justify the giving of a distinctive name to the beryl from Southwest Africa, we must first consider whether it is allowable to give a distinctive name to greenish-yellow beryls in general. This question may be promptly answered in the affirmative. Aside from the emerald a number of other beryls have received distinctive names because of their individual coloring. We have already mentioned the caesium beryl found in the State of Maine, which varies in tone from colorless or rose color to a bluish tint. The greenish blue beryls found in Siberia, Brazil, Madagascar, and elsewhere are known as aquamarines; all possible intermediate shades are found in aquamarines, from a sea green on the one hand to pure blue on the other, while some of them are colorless. But it is the custom, nevertheless, to speak of blue aqua marines and of white aqua marines instead of blue and of white beryls.

Morganite is a pink beryl, specimens from Madagascar exhibiting an especially beautiful color. Bixbite is a gooseberry red beryl from North America. A number of other names are applied in the United States to various kinds of beryls (compare "Gems, Jewelers' Materials and Ornamental Stones of California" by Lewis E. Aubry, Sacramento, 1905). I believe I am correct in supposing that these North American stones also include some of the same color of heliodor. . . . In view of the consideration stated above it is my opinion that the giving of a distinctive name to the beryls from South Africa, merely because of the difference in luminescence is unjustified. The rubies from Ceylon, Siam and Burmah differ greatly with respect to their luminescence, some specimens exhibit practically none while that of others is very strong—but no one would think of confining the name ruby to any one of these stones of different origin, merely because of this difference in luminescence. I may cite another example apropos to this: Mr. Hugo Wild of Idar said to me, of some colorless specimens of the precious topaz from Southwest Africa which I compared with similar stones from Brazil, the former gems showed a strong luminescence in the cathode rays, while those from Brazil showed none, yet it would be absurd to give the topaz from Africa a different name from that of Brazil.

It is my final opinion that distinctive names for the same mineral are justified only by a distinctive color which can be readily distinguished by the naked eye, irrespective of any variation of luminescence which can be detected only by a delicate scientific test.

ELECTRIC FURNACE REFRACTORIES

R. M. HOWE, in a paper before the Electric Furnace Association in Columbus in October, described the properties of refractory brick and discussed the raw materials employed in the manufacture of such refractories.

The fusion points of refractory brick are stated as follows in degrees centigrade: Fireclay, 1615 to 1715; silica, 1700 to 1705; magnesia, 2165; chrome, 2050; bauxite, 1565 to 1785; zirconia, 2563 to 2600; carborundum decomposes at 2240 and alundum fuses at 2050.

In the article, which appears in *Chemical and Metallurgical Engineering*, December 22nd issue, a proper use of these various refractories is discussed and the electric resistivity is given together with data as to the thermo conductivity of refractory brick at a thousand degrees centigrade and the resistance to temperature changes. In conclusion the writer states certain factors concerning the service secured from refractory brick. "They should be protected from rain while being stored in order to prevent the weakening of their structure. They should be laid up with a material similar to the brick themselves or one which would not corrode or flux them, using as small a joint as possible. The furnace should be constructed so that heating will be conducted away from the hotter portions. The ratio of heating to cooling area should be made as low as possible and refractory brick or shapes should be heated from one side only in order to keep the heating surface low and in order to avoid the effect of pressure and high temperatures. Insulation lowers the margin of safety and should therefore be avoided even to the extent of allowing dust to accumulate on the roof. When the furnace is being heated this should be done gradually, especially where magnesite and silica brick are involved. When a furnace is being cooled it should be remembered that cold blasts produce or accelerate spalling."

TWO SAMPLES OF NATURAL PATINA—A RICH, SOFT DEAD BLACK PRODUCED WITHOUT HEAT TREATMENT

Patina—Natural and Artificial

Various Methods of Producing Colored Coatings on Metallic Objects

By C. Powell Karr

THE name "Patina" is applied to the colored coating or incrustation more or less permanent, that is produced upon metals or their alloys, either by natural or artificial means.

The first and most beautiful coloring is produced by nature. The tooth of time is the best corrosive and the moisture of the air with its vapor laden with many different active gases is the best dip or wash that can be devised. The beating of the winds, the falling of rain and hail, the blanketing of the snow and the buffeting by the weather and the intermittent play of the sunlight produce, by a combination of mechanical and chemical action upon the object a softer tone, a deeper tint, a more ravishing effect than can be imitated by any or all of the ingenious devices originated by man for the same purpose.

All common metals and their alloys by exposure to the air are altered, little by little, until a permanent coloration or patina is brought about. Sulphuretted hydrogen, ammonium sulphide or other impurities of the air, such as carbonic acid, intensify the coloring. Oxides, hydroxides, carbonates and sulphides are formed on the surface of the metal. The coloring produced is various, in fact the whole gamut of colors visible to the naked eye, from yellowish brown through indigo, blue to green, to black. Inhumation of the object in moist earth for a long time will produce an effect almost as beautiful as that attained by exposure to the air and weather. Examples of natural patina formation may be seen in coins, medals, public statues, fountains and monuments everywhere. One of the most beautiful examples in all the world may be seen and admired by a study of the statue of George Washington, in front of the Subtreasury Building at the corner of Wall and Nassau Streets, New York. The upper parts of the statue above the knees are colored a rich, deep chocolate brown with a dull soft velvety patina. From the knees down, the rich lustrous glittering surfaces, rubbed down by the palms of some one's hands are colored by a combination of the oily moisture exuding from and rubbed in by those hands and the beneficent lapping of the wind and softened by the sunlight. The effect is incomparably rich and permanently beautiful.

The two little figures shown herewith in two different positions, were modeled after the celebrated Barye bronzes by an art-bronze sculptor and metal artisan of Italian birth and training, but now a good American citizen. Their composition is as follows: the standing figure has: 83% copper, 7% tin, and 10% lead. The recumbent figure has: 83% copper, 5% tin, 2% zinc and 10% lead. The original heats were made in an oil-fired furnace, poured into ingots by the writer, sent to Brooklyn, N. Y., where they were cast into these little figures by a well-known art-bronze founder. They have received no heat treatment, but have remained for four consecutive years in a steam-heated apartment in Washington, D. C., that was lighted by electricity. No gas was present except that from the kitchen range to which they were not exposed.

Both of them have the rich, soft dead-black patina referred to later, in an alloy that happens to be of the same composition as that of the recumbent figure. The vertical figure possesses a patina if anything a shade deeper and more lustrous than that of the recumbent figure. As beautiful examples of a natural patina on a small scale they could hardly be surpassed by anything of the kind ancient or modern now extant.

Some years ago the writer had occasion to make up a pewter alloy containing about two per cent of copper. After the casting the remaining metal was poured into a cast-iron mold. Out of sheer curiosity the writer watched the ingot mold. While undergoing solidification the coloring took place. At first a warm blood-red brown appeared, followed rapidly by a lapis-lazuli and azure blue, then by a malachite green, then by tints of pale mauve green, simultaneously by a purple of Cassius, by a soft delicate violet and finally by a red, brilliant, startling, flaming as the richest coloring of a dying sunset; then slowly by hazes of purple, violet, lilac and the pale pinks of a morning's late sunrise in November, with a transparency as clear as if they had been cast under molten glass or translucent enamel. This astonishing transformation fixed one's attention and held it spell-bound at such a color drama, with its bewildering abundance and variegation of blended and contrasted colorations.

The colors thus produced are not permanent. Upon continued exposure to the air—even of a closed room—they are attacked in such a manner that their brilliancy and glassy luster fade or become dull. The colors seem to run under

the transparent skin of the metal while it is still semi-molten, and are produced by a film of oxides on the skin of the molten casting; it is probably impossible to repeat or reproduce them upon spun or drawn metal of the same composition, such as britannia metal or pewter, because they originate only at the transitional moment from a molten to a solid state. It might be possible however to reproduce such a wonderful patina by the Parazite process referred to later on, or by suddenly heating such a drawn or spun surface in various places by playing a spirit flame upon it at different moments and then suddenly cooling the object by plunging it suddenly into a bath of liquid air. If such effects could be reproduced by artificial means it would bring back to the world the lost art of making pewter mugs, jars and pitchers—the wonderful and admirable creations they used to be.

ARTIFICIAL PATINA

Such coloring is a work of art. It obtains a subtle hold upon the admiration of man from a period reaching back to the dawn of the earliest civilization of the world. The Greek alchemists produced some of their color effects by the use of mercury and arsenious sulphide.

Everybody knew that in melting together 90 parts by weight of copper and ten parts by weight of tin a hard brittle alloy of yellowish color of bronze was produced. It was seen that a small quantity of tin mixed with molten copper furnished new properties and a golden color, and from these alterations of color they came to the conclusion that by similar changes base metals might be transmuted into gold. The coloring agents were covered by the family name of "The Philosopher's Stone." That by a corresponding surface treatment (surface alloying, treatment with mercury, arsenious sulphide, golden yellow, varnish, etc.), colored metals were denoted by the names of the imitated metals. A special object of metal coloring in ancient times was the bronzing of them, which was carried out with masterly effect. Since then bronze coloring has been shaded and varied by changing the proportions of the alloy, by artificial or natural oxidation, by naked corrosion and by gilding processes that produce a true patina formation.

In the most admired of the Japanese patinations are to be found methods which differ greatly from the art as practised by other countries. They found that by protecting parts of the surface of an object by shellac or varnish and leaving other parts exposed to the action of the corrosives they succeeded in evolving some striking effects. Also they combined their art of inlaying one metal or alloy with another and, etching the combination with the proper corrosive, attained brilliant results. Then too the metals they used were smelted from ores containing many impurities that they had not learned how to extract so that their supposedly virgin metals contained other metals not especially desired, but which at the same time secured to them enviable reslults. Cobalt is found in many of their alloys; it is there as an accident, not intentionally, but, having a wonderful effect when it is present in a copper alloy, its presence was turned to the best account.

ELECTROLYTIC PATINA

By anodic action a colored metallic coating is brought about due to the gases generated at the anode. In order to retard the evolution of the gas or to decrease it, gelatinous bodies such as gelatine, agar-agar, etc., are added to the electrolyte. In the best way the metal object is colored by placing the thickening material and the electrolyte in a clay or porcelain cell; the electrolyte at the cathode is left free and open. A solution of mono- or di-sodium carbonate ought to produce a dark brown; by the addition of a di-sodium thiosulphate a deep black coating results. By sodium acetate an olive green, by potassium ferricyanide and ammonium chloride a rich lilac coloring.

Black oxide can be applied to iron as well as to copper or brass. The solution consists of hydrochloric acid, 3/4 of a liter, water, ¼ liter; arsenious acid 25 grams, copper sulphate, 5 grams. First of all dissolve the arsenious acid in the hydrochloric acid, stir with a glass rod until solution is complete. For the other part dissolve the copper sulphate in a 1/4 liter of water (preferably not to hasten the reaction); to this solution add the solution of the arsenious acid. Then electrolyze the bath, taking for an anode a suitable sheet of iron; for the cathode use the object to be patinated. This object naturally should be scoured perfectly, as it acts upon the coating no matter what the metal deposit is. Employ two amperes per square decimeter of the surface to be covered; continue the operation during the time necessary to obtain the desired deposit. For copper and brass, cool down from a high temperature, polish with a little plug of cotton. The patina obtained is fine, susceptible of being revived and better still, burnished. In the last case the result is beautiful.

BLACK PATINA

Space will permit only a reference to this coloring as applied to brass. The brass article is polished and colored by an amoniacal corrosive as follows: 100 grams of copper carbonate is dissolved in 750 grams of ammonia of 0.96 spec. gr. (the commercial product), in which the corrosive is allowed to stand for several days in a closed vessel and frequently shaken; then 150 grams of distilled water is added. Some copper carbonate remains undissolved. The corrosive is cold or warmed to about 60° C. but not boiled. Since the air acts upon the coloring process the dipped objects are moved back and forth. The copper carbonate (basic carbonate of copper) can be used in the form of mineral blue, it is better, however, to precipitate it afresh, in which a soda solution is added to a solution of copper vitriol; both solutions to be hot, not boiling. (Under "Electrolytic Patina" see another method for obtaining a black patina.)

PATINIZING ALUMINUM AND ITS ALLOYS

The Parazite Co.G.m.b.H. Frankfort a.m. uses a proprietary solution called "parazite;" it is dark brown and transparent in color. The composition of it is a trade secret, but it is probably nothing more nor less than a paraffin or ceresine wax dissolved in a paradibromobenzene, or other benzene compound solvent. It is alleged that this solution does not attack the metal object that is to be colored, that it is absolutely resistant to acids, alkalies, atmosphere, etc. The solution is applied in thin or thick layers, according to its concentration, by means of brushing, dipping, or spraying as may be most suitable. It spreads easily, gives a smooth surface, even the brush strokes are not visible. The brown coating dries quickly. If the object be dried slowly, with a temperature rising gradually to 200° C. and left so for 25 to 30 minutes, then slowly cooled, at the beginning there appears a transparent coating of fast adhering, deep black upon the surface that is constant up to 300° C. (The decomposition temperature of paraffin.) It is claimed that by heating as described, and by the oxygen of the air the solution is polymerized and changed into another modification. The preparation is first melted, but by subsequent heating it is altered in such a way that no further heating is required. Carbon-disulphide and carbon tetra-chloride are solvents of paraffin wax but their boiling points are so low that it is not believed they could be used successfully in the above operation. It is admitted by the Parazite Co. that the patina obtained by their process is injured by the action of steam.

PATINATING BY HEAT TREATMENT

The surface of any alloy, especially one containing copper, is changed in its coloration aspect by the sudden application of heat almost up to the fusion point, followed by sudden or slow cooling. The color effects are more or less brilliant and permanent, respectively. Evanescent coloring may be made permanent by lacquers. This is a branch of the art that was greatly in vogue among the ancient alchemists and is now looked at askance by modern lovers of the art of patination.

The application of a hot gas or vapor to the surface of a metal or its alloys is just as logical and esthetic as the use of a solution of a liquid for the same purpose. We believe that such an attitude is a pose and not a sincere expression of a conviction. Any method that will bring about a coloration of a metallic surface, whether the result be evanescent or permanent, should be studied and developed. One art begets another art and although some of its creations may turn out to be grotesque or hideous, yet insensibly and subconsciously they point out the path to beauty and beauty always has been and always shall be its own excuse for being.

An alloy consisting of 5 parts of tin, 83 parts of copper, 10 parts of lead and 2 parts of zinc (by a singular coincidence the same composition as that of the recumbent rabbit of the illustrations) after polishing, if heated in a muffle furnace, quickly assumes the dead-black so greatly admired in Chinese specimens. Hitherto it has been found difficult if not impossible to obtain this depth of color with modern art bronzes, since the surface scales off when treated under similar circumstances. A different view, however, is that if to such an alloy, during its compounding, one per cent of cobalt be added, the dead-black produced by alternate heating and cooling will not scale off.

About a year ago the writer made up some test bars of the following composition: 90% copper, 6.5% tin, 1.5% lead, and 2% zinc. These were heat-treated in an electric muffle furnace, held at a constant temperature of 600° C. for thirty minutes; allowed to cool slowly over night in the furnace. The specimens have been lying with others in a storage bin since then. The surfaces of the test bars have the rich dead-black patina referred to above. The patina cannot be removed except by fresh chemical reagents. The patina does not scale nor peel off. The deep black is accounted for in part, probably by the lead that they contain. By rubbing the dull black with the fingers, the surface takes on a vivid lustrous black with a slightly reddish tint that seems to glint through the black, an effect that does not lessen its appeal to the eye. This test among many others of a similar character upon specimens of bronze varied in composition, but always containing some indispensable lead, shows that it is possible to produce upon a modern bronze a permanent patina—a dead soft ivory black matte or a lustrous dead-black with the forbidden red trying to gleam through its dusky mask.

Among the most beautiful patinas the world has produced is that devised in Germany by W. Elkan (D.R.P. 153308). It is a blood red or Dragon's Blood patina as it is sometimes called. It is produced as follows: Objects of copper or copper alloys are heated to a glowing red. The heat covers its surface with a film of copper oxide and cuprous oxide or copper suboxide. After cooling the object is polished with polishing wax until the black oxide film is removed and the sub-oxide deposit appears; in doing so the object attains an intensive red color, which at the same time shows a striking luster. Coloring and luster are so constant that the object may be treated by various chemicals such as copper vitriol solution without suffering any damage to its appearance. If a veined marble effect is desired, the surface, during the heating, is sprinkled with borax or other reducing agent. Wherever the surface is deoxidized by the reducing reagent the reddish virginal surface of the copper alloy appears and when polished a variegated or mottled effect like veined marble is produced after the final polishing.

Measuring Shades of Colors*

Dr. Ostwald's Mathematical Method of Defining Dye Tints

By Hans Heller

When we wish to make accurate measurements of a stretch of ground we make use of a graduated scale, so that we can obtain any required degree of precision expressed in divisions or multiples of a given standard, such as a meter—e.g. centimeters and millimeters on the one hand—kilometers, etc., on the other. Since the magnitude of these units of measure is exactly known and can be readily verified, the measurement of length offers no difficulty in practical life, and the same thing holds true not only of linear but of square and of cubic measure. Certain other values which cannot be reduced to measurements of space may still be easily recognized and represented by figures, such as the degrees of heat, amounts of pressure, and various others. The making of measurements where we have to deal with immediate sensory impressions as in case of notes of sound appears to be much harder, but this problem also is capable of being solved by "measuring" not the sensory impression but the corresponding *physical magnitude* which forms its basis. To every audible tone there corresponds one certain definite length of the sound wave which causes it or else a fixed number of such waves or vibrations per unit of time, the so-called velocity of vibration. The figures representing these velocities have been given names in the shape of letters of the alphabet compounded with certain words or syllables, and thus any note of sound can be measured with precision and so designated as to be generally comprehensible. Every lover of music knows what middle-C means and by means of such expressions (more exactly by means of their graphic representation in the form of musical notes) the chaos of sound tones can be mastered and set in order. But there is another immediate sensory impression, that of *smell* in which this method *cannot be employed*, and both the manufacturer and user are obliged to resort to the selection of certain well-known perfumes as standards and approximate measures of comparison.

And at first glance *colors* "the children of the light," which not only afford our eyes the liveliest pleasure from earliest infancy, but are the chief requisite for the formation of our concepts of the visible world—the colors with which we adorn ourselves and which form the medium of the artist—these too, appear to evade any method of *measurement.* Even men of science who have need of precisely defining mineral colors, dye stuffs, etc., and the technicians who require color designations and definitions, both in the textile craft and in countless others, even these men have felt obliged to content themselves apparently with inexact representations of more or less limited signification, such as "deep blue, sky blue, violet blue," etc., the apparently unlimited multiplicity of artificial dyestuffs has now, however, sternly emphasized the necessity of greater precision in the designation of shades of color. It is exceedingly troublesome and often enough quite impossible to make "color tests" when a certain color requires accurate naming. But when we look through the enormous handbook of dyestuff tables prepared by Schultz, we are unable to find any color terminology wherein *measurement of shade* is a factor.

The question "Can colors be measured?" which it is apparently difficult or impossible to answer, is obviously of a twofold implication. In the first place *what is it* that it is desired to measure? Helmholtz and most of the investigators who have succeeded him held the view that every bright color is characterized by three magnitudes which it is necessary to measure in order to obtain a quantitative definition—these properties being the color tone, the purity, and the brilliance. But the physiologist, Ewald Hering, has pointed out that these

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three properties cannot possibly be the elements which constitute a "color" quite aside from the fact that it is impossible to make an *absolute* determination of these three values so that it is necessary to rely upon merely comparative estimates. Hering's greatest service in the matter has been the relegation of the doctrine of color to that branch of science to which it properly belongs, namely, psychology. The sensation of color is obviously a mental experience and it is, therefore, in the domain of the intellect that we must seek for the answer to the question as to what constitutes the concept of color. Hering, himself, has largely solved this problem. However, we have been enabled to form certain *definite*—we will *not* say *final*—conclusions upon the subject, only quite recently through the researches of the celebrated physicochemist, William Ostwald, whose activities have been so manifold in various domains of science. . . .

We must first endeavor to obtain a clear idea of the concept of "color." Ostwald understands thereby merely the mental process by means of which we become conscious of color, no matter what the cause of the experience. This internal process to which we apply the name color undergoes profound alterations according to the circumstances which condition it . . . for example, let us lay a piece of bright colored paper, preferably yellow, upon a table standing by a window in the brightest possible sunshine. Then let us cut a circular hole about 2 cm. in diameter in a second piece of stiff white paper. Now let us hold the white paper at a distance of about 30 cm. above the yellow paper so that the latter can be seen only through the circular hole in the corner. If we now gaze through this hole it appears to our eye *at first* but not constantly, as a yellow circle in the middle of the white surface, but if we turn the white paper away from the window, so that it is in the shadow, the circle assumes a *brilliant yellow* aspect. If we now slowly turn the paper toward the light once more this vivid yellow begins gradually to lose its brilliance becoming increasingly duller, then grayish yellow, olive green, until finally when the white paper is receiving the full brilliance of the sunlight, the eye receives the impression of a blackish yellow circle in the middle of the pure white surface (of course, care must be taken to prevent a shadow from falling upon the yellow paper. . .). This is certainly a very remarkable and surprising experiment; although the color tone of the lower paper, as well as its purity and its brilliance, have remained *absolutely unaltered*, yet the color of the visible section has apparently changed gradually from a vivid yellow to a dark yellowish gray, passing through the most various intermediate shades! Here, as we see, the actual yellow color of the dyestuff has remained unchanged while the sensory impression has undergone manifold alterations. This experiment indicates that "color" is a mental process.

But let us now consider the *cause of this apparent change of color*. We can see readily enough that this change must be due to the fact that we have regarded the yellow circle in a constantly changing environment. Through a mental process which is entirely independent of our own will, we connect the two impressions with each other—we relate the color impression of the circle to its environment. For this reason Ostwald terms such colors *related colors*. It will readily be seen that impressions of such related colors are the general rule in our daily experience of color. We are constantly finding ourselves in varying circumstances through which our impressions of color are extensively influenced. . . . Let us make a parallel experiment: A tube having a blackened interior is closed at one end with transparent colored gelatine, a yellow filter, cobalt glass or the like. If we now place the eye at the other end of the tube, at the same time looking in the direction of the window, we perceive a surface of uniform color in an entirely dark environment. If, for example, we have once more chosen the color yellow, we perceive a brilliant yellow circle in a black field. If we now turn the tube slowly away from the window toward the darker room, then the *luminous intensity* of the yellow steadily diminishes, whereas the yellow as a *color* remains *constant*. And even when we are looking toward the darkest corner of the room we still receive an impression of a surface which is yellow though strongly shadowed. But at no time do we perceive the muddy yellow and olive green tones which we observed in the first experiment! The alteration of the intensity of the light, therefore, does not produce a change in the tone of the color in a dark environment, but merely occasions varying degrees in the brilliance which changes from the most intense to the palest tone. The reason for this lack of any alteration of the color tone evidently resides in the fact that there is no *relation* or reference to the surroundings which here exert no optical effect. Such colors are termed by Ostwald *unrelated*. They are found as a rule in all optical apparatus and, indeed, hardly anywhere else.

But what is the essential difference between related and unrelated colors and what is their bearing upon the measuring of color? When we examine *unrelated colors* with respect to which of their elements are alterable in the mental process, we find that there are two in general: (1) the color tone; (2) the brightness, for it is possible for me (1) to place either a red or a yellow object or one of any other color in front of my tube; I have, therefore, a choice of the color tone at my command. I can, likewise, (2) alter the brightness of any given color tone at will by varying the intensity of the illumination, but since this illumination is always accomplished by means of sunlight, *i.e.*, of *white* light—in other words light consisting of all possible wave lengths, then we may draw the inference: in unrelated colors the color tone and the content of white (*i.e.*, the degree of brightness) are alterable. This exhausts the possibilities and the *measurement of unrelated colors* is, therefore, attainable provided that both of these magnitudes can be determined—and, moreover, determined *quantitatively*.

Related Colors.—The case is different with related colors. Here, too, however, the color tone (1) can be chosen at will, while the content of white also (2) varies within the same limits as in the case of unrelated colors: the character of the first experiment will be in no way affected when its vividness is diminished because of a weaker illumination of the yellow paper. It is the influence of the environment (3) which is constantly to be regarded as alterable. This third magnitude, which is capable of causing related colors to appear to be so much more manifold must, therefore, be measured in order to find a mathematical expression for the measurement of related colors—*i.e.*, consequently for *all* the colors known to us. How shall we accomplish this?

In order to answer this question let us recall the general phenomena of colored bodies . . . when white light falls upon a body, either all the light is *reflected*, in which case the body appears to be white, or else all the light is absorbed, in which case we call the body black. Between these two boundaries lie all the cases in which the light is partly absorbed and thus weakened; these colors we refer to as "gray." These include the so-called neutral tones, *i.e.*, those which do not possess a color tone in the ordinary sense of the word. It is evident that we *are* able to measure such colors. This is accomplished in practice by the ordinary methods of photometry. *Absolute black* can be achieved in the Kirchhoff box, a black box containing a small opening. A coat of specially precipitated barium sulphate can be employed for standard white. In this case we measure merely the *luminosity*, *i.e.*, the *relation* between the quantities of light received and those reflected, hence we are concerned here with *conditions of reflection;* and these are determined merely by finding the percentage of "black" in the reflected light. This proportion or *content of black* is the third alterable factor in the value of related colors. At first thought this seems rather astonishing since obviously the bright colored filter placed in front of the dark tube in our second experiments, likewise permits only a portion of the total amount of light to enter the eye, so that

even with the fullest degree of illumination there still remains a content of black. Just here there is revealed, however, the basic importance of the relatedness or non-relatedness of the color to the environment. Since it is impossible for us either to have or to form an opinion as to the strength of the illumination in the case of unrelated colors, neither can we in general form an opinion as to the conditions of reflection! We cannot give in this case an extended explanation of these conditions which are not readily made comprehensible, but we may state in brief the manner in which the color tone is to be conceived of and measured.

Thus far we have taken the question of the reflection or absorption of white light merely as a basis for the discussion as to how the phenomena of the gray or neutral tones are produced. But we know that "white" light can be split into its components by a prism and is then seen to be made up of the colors of the spectrum, *i.e.*, of *bright* colors. Observation of these has shown that every color tone in the series corresponds to a certain wave length of electro-magnetic vibration. The brightness of the great majority of natural objects, *i.e.*, their *gay colors*, depends upon the circumstance therefore that it is not white light—*i.e.*, light constituted by *all* the wave lengths—which is reflected, but that certain waves which are characteristic for any given substance, are absorbed. But since the totality of wave lengths has the appearance of white, whereas any separate portion is colored, most substances appear in bright hues. But *besides* this partial absorption of certain rays of light there occurs, even in the case of those colors which appear to our eyes the purest or most perfectly "saturated," a certain amount of *general absorption of the total wave lengths*, so that any given color of an object contains not only its own color tone, but also a certain proportion of *gray*. This leads us to the obvious conclusion that the color tone can be determined only by a comparison of it with the *pure tone* which resembles it in spectrum, and that it can be "measured" by determining the wave length of the aforesaid pure tone which is a comparatively simple thing to do.

And just here lies the further service for which we are indebted to Ostwald—he points out, namely, that the common opinion that a "saturated" pigment or dyestuff reflects light of only *one* wave length is entirely erroneous; even the most beautiful yellow pigments of exceptional purity which it is possible to prepare by physical means, do not as a general thing reflect the corresponding pure yellow of the spectrum, but also throw back to the eye numerous waves of approximate length. As a consequence of this the *color tone cannot be expressed by figures representing wave lengths*. This is especially evident in the so-called *purple colors* which lie between red and violet, but as a general thing do not appear in the spectrum at all.

By means of this long-winded and yet really essential introduction we shall now find ourselves able to comprehend how colors can be measured. We shall explain here merely the basic principle without entering into the technical details. In accordance with the foregoing remarks there are three factors which enter into the determination of a color, namely, the color tone, the content of white, and the content of black.

. . . In the well-known experiment of illuminating a dark room by a *monocolored flame*, the aspect of ordinary objects undergoes a drastic change. When, for example, a gas flame is colored yellow by ordinary salt those objects which always observe the yellow rays from white daylight, naturally do the same thing in the yellow light—hence they reflect no light and, therefore, appear to be "black," whereas objects of a yellow color or *those which reflect many yellow rays*—appear on the other hand to be a pure white color, since a "white" object is merely one which reflects to our eye *all* of the light which it receives. This is why the hands and faces of the spectators look white and their ghostly aspect is not easily forgotten. The measurement of the purity of any given color in a colored object is accomplished in a similar manner. Let us imagine a spectrum of sufficient length thrown upon the screen and let us then take the object to be examined, e.g., a green leaf or the like, and pass it through the band of colored light—it will vary in apparent ripeness according to the color of the light which happens to fall upon it at any given moment of its progress. In that portion of the spectrum whose color tone is "like" that of the object being tested, *i.e.*, at that part of the spectrum where *all* of the light which falls upon the object is reflected, the latter will appear to be pure *white;* in that part of the spectrum, however, in which all of the light is absorbed the object will appear, on the contrary, to be absolutely *black*. But it is possible for me to compare the amount of the reflection in the two cases with that of a neutral gray pigment, the conditions of whose reflection are already familiar to me. Moreover, I can represent upon a decimal scale (divided into 100 parts) the content of black or white in the aforesaid neutral gray. Now the luminosity (represented by the symbol h_1) in the first described case may be considered to be composed of the following factors: the content of white (W) of the bright colored object plus the percentage of pure color (R), since the latter is also entirely reflected. This gives us the following equation:

$$h_1 = R + W$$

In the second case the luminosity which is measurable by means of a comparison with the previously measured gray, consists only of the percentage of white contained (W), since the pure color (R) is absorbed while the content of black produces no immediate effect; hence we have the equation:

$$h_2 = W$$

But as we know the total color of our green leaf comprises three factors: the pure color tone R, the content of white W, and the content of black S, hence:

$$R + W + S = 1, \text{ or}$$

$$R + W + S = 100, \text{ in the decimal scale.}$$

We first obtained from our measurement the value of $R + W$. Substituting this value in our first equation we obtain:

$$h_1 + S = 1 \text{ or}$$

$$S = 1 - h_1$$

thus we have *measured* S the content of black, and we have likewise measured the percentage of white, W, by means of h_2. This *readily enables us to calculate the content of pure color* according to the following equation:

$$R = 1 - (W + S).$$

We are now in possession of all the factors required for the *quantitative determination* of any color of whatever nature. It is well to keep in mind that the measurement of the percentages of white and black is *absolute*, *i.e.*, independent both of any sort of theoretical speculation and likewise of the intensity of the light employed, since the gray used in the comparison is subjected to the same illumination. Accordingly, Ostwald is justified in his statement to the effect that "the discovery of the absolute measurement of the purity of colors constitutes the most important progress attained in our knowledge of pigments." On the other hand it is of little importance that we are obliged to make use of an arbitrary principle for the purpose of naming colors. This arbitrary principle consists of the *color circle* proposed by Ostwald.

The so-called color circle consists of the arrangement of pure color tones in a circle in such a manner that the complementary colors stand opposite each other, and so that the shade produced by the optical mixture of equal parts of any two given color tones lies between the two. Such color circles are by no means new, having been previously arranged in various systems. Ostwald composes his of 100 tones. The reader may inquire: "Why only 100?" We may answer this by saying that while it is true that there are innumerable stages between the pure color tones, yet we have learned from experience that only about 100 of these stages or degrees can be definitely recognized. These are quite sufficient in practice and intermediate stages can be estimated, while as a matter of fact beyond certain limits (the so-called "psychical threshold value") the eye ceases to be capable of making

distinctions. In this color circle, therefore, we find all the *pure color tones* and *also the purple tones* which are lacking in the spectrum. . . .

Pure lemon yellow is marked zero because it is the most brilliant of all color tones; red is represented by 25, while 50 corresponds to ultra-marine blue (U-blue for short), 75 to sea-green, etc. By means of this scheme every color can be precisely identified by means of three mathematical expressions. For example, we may take the following:

30 x 12 x 51: the signification of this is as follows: 30 is the number of the color circle, *i.e.*, in the vicinity of carmine red; 12 is the content of white which is thus very small so that the red in question will appear to be very "deep" in tone; whereas the 51 per cent of black is not so strongly noticeable as might be expected. This gives us the impression of a comparatively pure saturated red. The percentage of pure color in this case would be represented by $100—(12 + 51) = 37$.

Thus we have attained our object of a mathematical representation measuring each color. Every imaginable mixture of black and white with the pure color tone from the clearest purple to the dirtiest brown can be represented by three figures arranged as above. This gives us some idea of the profundity of the problem thus solved by Ostwald. A description of the matter is to be found in the work *Introduction to the Study of Color* (in German) in Reclam's Universal-Bibliothe No. 6041/44. . . . These results are already being employed in the domain of art. Thus, the industry of porcelain manufacture in Saxony has already employed, with great success, Ostwald's great color atlas, thus offering the first proof of its utility.

REPORT OF THE CHEMIST

THE work of the Bureau of Chemistry for the fiscal year ending June 30, 1919, has but recently appeared, but the 24-page pamphlet is worth careful examination since it indicates how wide is the field and how important the work of this scientific bureau of the Department of Agriculture. In addition to the large amount of work incident to the enforcement of the Food and Drugs Act researches have been conducted on sugars, sugar derivatives and syrup, and of these problems an interesting one is the project to produce a uniform cane syrup that will neither ferment nor crystallize. Work was well under way when it became difficult to obtain a kind of yeast necessary for the process and the research has now turned to an effort to obtain a satisfactory substitute. It appears that certain molds which are easy to grow may form sufficient of the enzyme invertase to make it possible to employ them in the place of the yeast.

Fats and oils have been an important part of the research and a bulletin upon the production and conservation of fats and oils in the United States has been issued. The demand for this first critical survey in the oil industry and traffic of any country has been great. The physiological chemical examination into the nutritive value of the oil-bearing seeds has received much attention and has thrown light upon the cause for the completeness of the Oriental diet which has seemed poor and inadequate to the average American. Data derived from these researches shows that cocoanut globulin contains all the basic acids necessary to growth and that it as well as crude cocoanut press cake is capable of supporting growth. These and other findings justify the opinion set forth in an earlier report that it is very desirable to retain a corpora crush industry developed during the war in this country.

Sea foods, poultry and eggs, dairy products, beverages, citrus by-products, flour and cereals, have all come in for their share of attention. Paper and fabrics, naval stores, leather and tanning, color investigations, containers, insecticides and fungicides and the dehydration of fruits and vegetables are the subjects of other interesting paragraphs. Researches into the causes of spontaneous explosions and fires in grain mills, elevators and cotton gins are also reported. Plant chemistry has included research on the seeds of about forty plants mostly grown in Illinois to determine their content of essential oils, and seeds from the varieties from which the largest yields of oil obtained have been planted at the experiment farm for further study.

CHINA'S OLDEST INVENTIONS

BY H. K. T. LOH

THE following is the result of a research through some oldest Chinese literature with the object of obtaining an authentic account relating to China's civilization in the line of literary and industrial inventions. No exact dates can be secured, however, on account of the fact that most of the books indicate only the names of the inventor or just an approximate period. Thus, here only the periods or dynasties are put down. As for the result, due to the lack of some important references which the writer cannot secure here, it is, of course, not complete. Besides, here are recorded only those which have relatively high value upon the latter development and those which bear deep significance on the early civilization.

From 2800-2698 B. C.—Ropes made of grass, and earthen pots. By Suy Jin.

Fishing net, cloth of hemp, and musical instruments as bamboo pipes. By Paou He.

Grass mat, wooden plows, bamboo combs, iron axes and earthen jars. By Shin Nung.

From 2697-2598 B. C. Under the Great Ruler Huang-ti.—Rough pottery, rough rice mill, spinning wheel, mirror, scissors, cooking utensils, water click, umbrella, dyes and magnetic needles. By Huang-ti.

Boat. By Ku Hua Wu.

Carriage. By I-yi.

Carving on wood. By Tso-che.

Rough astronomical instrument. By Yung Ching.

Tang Dynasty, 2357-2256 B. C.—Embroidery, wine, carving on stones.

Sung Dynasty, 2255-2206 B. C.—Painting and coffin. By Sung.

Hsia Dynasty, 2205-1784.—Metallurgy, tables, chairs, etc., sails and oars. By Yu.

Ying Dynasty, 1783-1123.—Candles, copper utensils, gold rings, earrings, etc., toilet powders from leads.

Chow Dynasty, 1122-247 B. C.—Bamboo curtain. By Chow Kung.

Sun dial, copper coins round in shape with a square hole at the center, shields and spears, elementary trigonometry, carpenter's plane and chisel. By Lu Pan.

Chinese ink. By Ying-yi.

Chinese ink stand. By Chung Yu.

Elementary machines began to be used in this period as derricks and automatic ladders. The latter was used during the siege of the capital of the kingdom of Sung by the kingdom of Tsoo. Their inventor was Kung Shoo Pan.

Ching Dynasty, 246-207 B. C.—Wonderful bows from which arrows were propelled with a slight touch on it. The one who touched it could instantly be killed.

Han Dynasty, 206 B. C., 219 A. D.—Paper. By Tsai Lun. The materials used were cloth, hemp and trees. (Before this time words were written on cloth and bamboo slips.) Sugar. Coal was discovered during this period.

The Period of Three Kingdoms, 220-274 A. D.—Turning carriage used in gardening. By Ma-chung. It poured out water contained in the carriage automatically.

Wooden animals used in pulling carriages. By Choo Ko Liang. It was also written in the history that Ma-chung could make wooden idols to beat drums and blow pipes.

Tsin Dynasty, 275-588 A. D.—Steel. By Chiwu Hwae-wan.

Suy Dynasty, 589-626 A. D.—Glass, improved water clocks.

Tang Dynasty, 627-935 A. D.—Gunpowder.

Five Kingdoms, 936-959 A. D.—Printing. By Fang Tao.

As this investigation is based on facts about the oldest inventions from the opening of the historical period to 1000 A. D., all the others later than this date are excluded here.—*The Little Paper* (Manila, P. I.), Nov. 17, 1920.

THREE YEARS' TEST OF SHINGLE ROOFS TO DETERMINE ADVANTAGES OF PAINTING

Note fungus growth and warping of the unpainted shingles in the cut at the left as compared with those in the cut at right, which were painted with fire-resisting shingle paint

Spray Painting*

Recent Developments in the Application of Paint with the Air Brush

By Henry A. Gardner

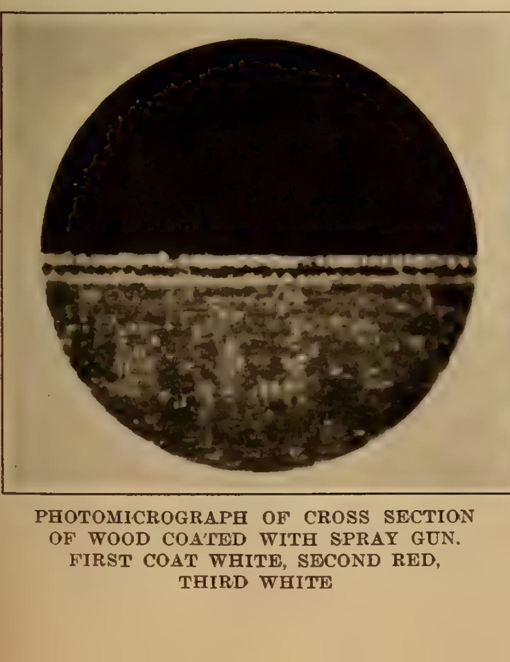
THE use of the spray gun for painting has encouraged a broader use of paint, especially for interior purposes, and has developed a wider demand for the services of the painter in general. Millions of square feet of wall and ceiling area in factories, which might not otherwise have been coated, are now being sprayed with interior paints of high reflecting properties. Such work has, in turn, created a wider use of paints for surfaces that can only be successfully done with hand brushes. As an illustration, the writer remembers one large factory, the owners of which apparently did not care to pay the cost of applying paint by brush. This factory was subsequently spray-painted with industrial white. The dado and the striping, of course, were found to be more successfully applied with hand brushes. The tremendous increase in light that resulted from the reflecting properties of the paint, coupled with the fresh, trim appearance of the mill, made that section that was partitioned off for offices look gloomy by contrast. In a short period of time all of the offices were transformed by the use of paint, and for this use the hand brush was employed.

*Paper presented before the Pennsylvania State Association of Master Painters, Reading, Pa., January, 1921.

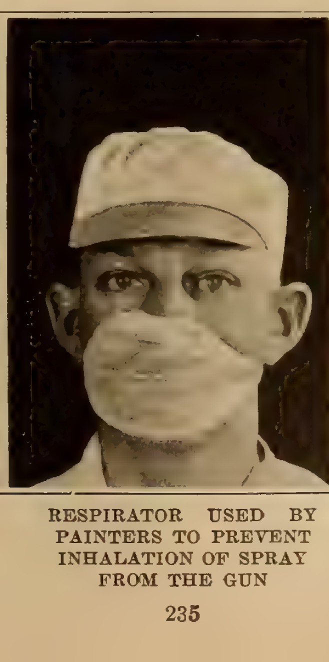
It would appear to the writer, as a result of this and other similar instances that have come to his attention, that the application of paint by any means (from the woman who paints the chairs in her kitchen to the spray painting of a mill), will be reflected in a broader use of paint and consequently increase the demand for the services of competent painters and journeymen. In the following text there are presented a few observations made during the past year and several illustrations that may be of interest.

Durability.—The tests of spray versus brush painting, conducted at the U. S. Naval Hospital in September, 1919, and described in the pamphlet entitled "A Study of the Practicability of Spray Painting," were inspected during December, 1920, after exposure of about fifteen months.

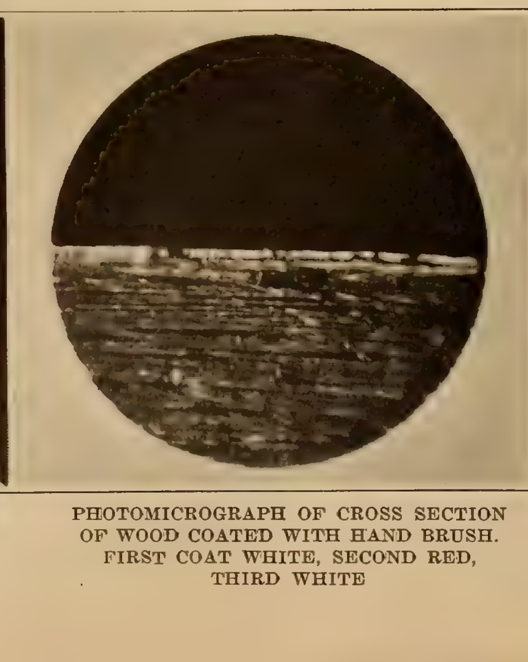
It will be remembered that the exterior brick walls of the building were painted with a light buff paint, one-half of the area being brush-coated and the other half spray-coated. The wearing properties of the paint applied by the two methods



PHOTOMICROGRAPH OF CROSS SECTION OF WOOD COATED WITH SPRAY GUN. FIRST COAT WHITE, SECOND RED, THIRD WHITE



RESPIRATOR USED BY PAINTERS TO PREVENT INHALATION OF SPRAY FROM THE GUN



PHOTOMICROGRAPH OF CROSS SECTION OF WOOD COATED WITH HAND BRUSH. FIRST COAT WHITE, SECOND RED, THIRD WHITE

seem to be almost the same, both coatings being in fair condition. Medium chalking has developed and some unevenness of the yellow tint is shown in the form of light colored spots. The latter defect, however, is often characteristic of paints

DAYLIGHTING A FACTORY
Note extension spray equipment

tinted with ochre. Close inspection of the two surfaces with a high power magnifying glass indicates a rather characteristic spatter effect where the paint was applied by the spray gun, and ridgy brush lines where the paint was applied by brush.

Inspection of the large roof area painted with red oxide paint showed that the brush-coated and spray-coated paints are giving equal satisfaction from the standpoint of durability. Where the paint had been applied with spray guns by workmen not acquainted with this method of application, excess quantities which were piled up in some instances, had run together with the formation of a somewhat wrinkled film in spots. Such films, remaining rather soft, necessarily took up dust from the atmosphere and became slightly darker than the areas coated with thinner films.

Due to the fact that the spraying machine, especially in the hands of inexperienced operators, is apt to apply a larger quantity of paint over a given area than the hand brush method, the heavier film would, of course, show slower drying properties. With certain paints, therefore, which are ordinarily made with raw linseed oil and a minimum of drier and thinner, slow drying properties might be observed. In such instances, the use of a substantial percentage of a rapid drying reducing oil of the varnish type would overcome this difficulty. A small percentage of a heavy bodied blown oil to cause "flowing out" and thus obliterate spray pit marks, might also be advocated. Manufacturers of special spray paints might take these points into consideration.

Paint and Industrial Relations.—The use of paint is bound to play in the future a very important part in the establishment of proper industrial relations. Cheerful surroundings in a factory make more contented employees and increase the quantity and quality of product. Proper illumination through the application of wall and ceiling coatings of mill white is now recognized by factory executives as one of the most important means of obtaining these results. For instance: James Copeland and Graham Lee, in writing on the subject of "Insurance and Safety," refer to a group of 106 Southern cotton mills as follows:

. . . "The precautionary measures taken inside of the mill are even more vigorous than those employed on the outside. In the first place, the mills of today are constructed so that they are not only efficient from the manufacturer's standpoint, but are healthful from the worker's standpoint as well. There are many big windows which let in a world of sunlight. To augment the flood of light that comes in through these windows, nearly every mill interior is painted with a specially prepared white paint which has a satinlike finish and reflects the light as it comes in through the windows until the mill interior is almost as light as day." . . .

Answers to an inquiry made among users of spray guns for applying industrial whites, state that on an average one workman can apply as much paint as six brush hands; two men being able to apply at least 50 gallons of paint in one day by well regulated spray guns.

Sanitation.—In considering the subject of sanitation, the thought was advanced during the discussion at last year's meeting that painters working in rooms with a spray gun might be subject to the inhalation of small amounts of paint that had been finely comminuted and dispersed throughout the air. Accordingly, workmen in certain places have been provided with various types of masks, helmets, or other devices. Most of these are heavy, difficult to keep on, and expensive. The writer has devised a type of mask which is sanitary, light in weight, easy to adjust, and very low in cost. The design, with representative home-made samples, was turned over gratis to manufacturers, and the product is being made in considerable quantities. It consists of two sheets of gauze containing a pad of absorbent cotton filled with a small amount of activated charcoal. The mask is cross-stitched and so arranged that it will fit closely over the nose. A detachable elastic band is provided to go around the head. The purpose of the activated charcoal is to absorb the vapors of benzine, acetone, or other volatile solvents. The purpose of the cotton is to keep out dust and particles of pigment. Reports

SPRAY PAINT TEST AT THE U. S. NAVAL HOSPITAL

from several users indicate that it has been found quite practical and successful in application.

Community Painting.—Many observing individuals have pointed out that on their trans-continental tours they have

been impressed with the lack of paint on structures in many communitifies. This condition, however, is not always to be attributed to the property owners' negligence. For instance, in many farming communities there may be a so-called painting season, in which the country painter is called upon to do more work than he can possibly handle. Consequently many buildings are neglected, and the owners hold over their painting work from year to year. Again, while some farmers fully appreciate the value of painting, they realize that the application of paints is an art, and if the local painter is not available to do the work, the job is left undone. In some communities there are no painters, and the farmer must do his own painting or let it go. The latter procedure often prevails, and results in rapid depreciation in property values.

PAINT SPRAYING A DWELLING

Note the trailer outfit

There seems, however, to be a rapidly growing movement throughout the country for community spray painting. For this purpose there are provided trailer outfits comprising a small truck upon which has been mounted a portable spraying machine operated either by electric current or gasoline engine. Supplies of hose, ladders and painting equipment are also included. With such an outfit the barns, dwellings, fences, silos and other outbuildings on several places in a farming community may be painted in a very short period of time. Because of the rapidity of application by this method, substantial savings may be effected. It is believed that this method of painting will become more universal in the future and thus help to fill that gap between demand for and availability of labor that often exists.

Spraying Shingles.—The potential use of paint for shingle roofs is immense. In every agricultural and suburban section there are thousands of structures with shingle roofs that have not been painted. The modern demand for a fire resistant type of roof now makes it important that all shingle surfaces should be coated with high grade mineralizing paints. Through the use of such paints, shingle roofs become fire resisting and waterproof. A glance at the condition of the many roof tests being conducted at the Shaw Botanical Gardens in St. Louis by H. V. Schrenk in coöperation with the lumber and paint industries, at once forcibly illustrates the value of shingle paints. The spray gun is very well adapted for the rapid coating of shingle surfaces, and the possibilities of the community spray gun for this purpose are apparent.

Decorative Purposes.—For interior decorative purposes, unlimited possibilities are opened up by a type of spray gun recently brought out by one manufacturer, which consists of a portable air compressor, including a motor, and gun attached to a small paint container. The total apparatus weighs less than 100 pounds and is so arranged that it may be attached to a standard electric light socket in any room. With pressures of from 4 to 10 pounds and by varying the distance of the gun from the work, extremely artistic two-tone color effects, including those which resemble Tiffany finishes and oatmeal paper, may be produced. It is understood that only extremely small amounts of paint mist are observable in the air when spray guns are used at such exceedingly low pressures, and that for this reason there is far less danger of soiling floors and the furnishings of a room when walls are being decorated by this process, than by other methods.

Imitating Mother of Pearl*

Methods of Producing Coatings Having an Iridescent Luster

By O. W. Parkert

It is not generally known that the art of imitating the pearl and its close relative, mother of pearl, is very ancient. Almost since history began artisans have been trying to obtain the iridescent luster of mother of pearl by means of mixtures of various pigments. The methods that have been devised for this purpose necessarily have been very numerous. In certain Chinese books, about 3,000 years old, mention is made of certain formulæ in which different substances are compounded and from which mixture pearls can be made, possessing a high brilliancy of color. During the course of the centuries the attention of technologists was turned to this problem, and in the workshops of these investigators Nature was forced to yield her secrets. After considerable study, lasting over a period of many years, the way in which the pearl is formed in the shell of the mollusc was discovered, and, as a result, a plan of artificial cultivation of pearl-bearing oysters was developed. This was the outcome of careful and very laborious research. Very good imitations of the pearl have been made from various artificial substances such as glass preparations made from fish scales, etc. The results of these labors opened up the road to the afore-mentioned goal, namely, the reproduction of colored opalescent effects, resembling the mother of pearl iridescence, on various materials by means of paints and other analogous coatings.

*Translated for the *Scientific American Monthly* from *Kunstoffe*, 1920, 129-130.

At the present time there are many kinds of substitutes for mother of pearl on the market. The way these are made and what they actually consist of are so well known that it is needless to discuss them here. In the first place, there is very little to be said about them that is new, and in the second place, much better results can be obtained with the use of iridescent paint coatings, which can be applied to any sort of substance and which then will give them the superficial appearance of mother of pearl. As can be understood very readily, the methods of obtaining these substitutes for mother of pearl have differed very greatly.

For example, in the case of certain materials, as glass, porcelain and the like, the opalescent coloring can be acquired without any difficulty by the addition of certain zinc salts in the course of manufacture, whereby the objects are subjected to the action of the vapors of these salts during burning. However, the task is a much more difficult one when the material to be treated is wood, horn and other similar substances.

THE USE OF GELATINE COATINGS

A certain iridescence can be obtained by coating objects with a gelatine composition, containing a very small quantity of an insoluble silver salt. The opalescence is improved very considerably when an additional thin coating of transparent collodion is applied. On the average, the composition of the gelatine consists of 5 to 7 per cent of its weight in potas-

sium bromide, ammonium chloride or ammonium bromide. First, the objects are coated with this mixture and then a solution of a silver or mercury salt is painted on the gelatine film. After this has dried thoroughly, a coat of collodion is applied.

This method of obtaining iridescence is basic in its principles and from it newer methods of imitating the pearl were developed. All the truly practical processes are based on the fundamental principle of breaking up the rays of light, which are refracted from the surface of the coatings by the use of several superimposed films. This is the way in which Nature forms the genuine pearl itself.

LEDUC'S METHOD OF MAKING IRIDESCENT GELATINE

Dr. Leduc of the University of Nantes in his work entitled "The Chemical and Physical Relations in Life," describes in some detail a method of producing iridescent gelatine. A ten per cent gelatine solution is made and for every 5 ccm. a drop of a solution of calcium nitrate is added. The gelatine is then spread out on a glass plate and, as soon as it solidifies, a mixture of dibasic calcium or sodium carbonate and phosphate are allowed to diffuse through it. The best proportion is 2 parts of carbonate for each part of phosphate. The tribasic phosphates of the alkali metals yield fine results without the addition of carbonate. Tribasic calcium phosphate will result in the formation of beautiful fine stripes in pure gelatine. A saturated solution of silver cyanide in potassium cyanide will give a handsome lattice-like appearance to the same substance. When the solution is allowed to drop on the surface of the gelatine, the circular regularly arranged effects are produced.

When the solution is applied to the gelatine between rectilinear parallel glass plates, then regularly spaced rectilinear bands are obtained. The grating effect, produced in a colloidal substance by calcium phosphate is not any different from the luster of the natural mother of pearl and the pearl itself. The chemical structure and composition are identical. The physical properties of the artificial product, the rainbow coloration, the luster and the fire in the color are quite like the play of colors in the genuine mother of pearl.

THE INTERFERENCE OF LIGHT RAYS

Liesegang[1] was the first to formulate the theory that the iridescent surface color of the pearl was due to the interference in the light rays refracted through several very thin films. Hence, it was only a question of coating the objects with a number of suitable substances in solution, which would dry out to form thin transparent films. For this purpose soaps, rosin solutions, petroleum and various lead salt solutions were found to be most useful.

IRIDESCENT COATINGS ON PAPER

Besch, for example, produced the iridescent effect on paper by allowing the paper to float on the surface of a solution of lead and bismuth salts. Then the paper is dried and subjected to the action of hydrogen sulphide gas. When the dried film is coated over with collodion the opalescent play of colors, characteristic of mother of pear, is obtained.

Another formula for obtaining the same results consists in dissolving one part of sugar of lead in 5 parts of boiling water and adding thereto another solution, consisting of one part of gumarabic in 3 parts of water. The object which is to be decorated is painted with this boiling liquor, allowed to dry and then coated over with a top coat of varnish, consisting of one part of Damar rosin in six parts of petroleum ether.

THE USE OF POWDERED MICA

Attempts have been made to get the same effects on wood by the use of powdered mica, but the results have fallen far short of the expectations. The preparation, made from fish scales, when used pure and with the help of gelatine or rosin varnish, gave thick silver-like films but without any opalescent luster. Many of the imitation mother of pearls are useless practically, as the processes devised for making them do not admit of industrial application.

IMPORTANT PATENTS

Numerous patents have been taken out on processes for producing artificial mother of pearl, but most of these are not of any great importance as many of the processes are really intended for other purposes. The most important patent, as far as we are concerned, is German Patent No. 113114 on the manufacture of iridescent gelatine films. The gelatine is first provided with an insulating coating of chalk, barite (BaSOA), metal bronze, zinc white and the like, and then is dipped in a bath containing as little of the solution as possible. This is done by pouring into the vessel a mixture of one part of nitrocellulose, 75 parts of 95 per cent alcohol and 20 parts of ether in water. When the gelatine foil is drawn out of the bath a thin skin forms on it, which, when dry, gives the characteristic iridescence of mother of pearl. It is of advantage to add some benzine to the iridescence producing mixture. Another composition contains 10 parts of potassium silicate and 90 parts of water.

According to German Patent No. 126675 the aqueous solution of gelatine is mixed with ammonium bromide, the dried product is dipped into a silver nitrate solution, dried again and the film is finally covered with collodion.

THE AUTHOR'S OWN PROCESS

This process is an outcome of long experience with the various processes in use, and can be employed for different purposes. It has always given the best of results. Wood, horn and similar materials are painted over with a coating of albumen, collodion or varnish lacquer before treatment, while paper, textiles, etc., are given a coat of gelatine, which is hardened afterward by treatment in a formalin bath. The resulting products are then coated with a gelatine size which should contain about 1.5 per cent of ammonium bromide to give the best results. This coating is allowed to dry and then another coat is applied, which consists of a silver nitrate solution, containing 1.3 per cent $AgNO_3$.

The next step is to dry the nitrate coat thoroughly. Then still another coat of a composition containing gelatine and from 0.15 to 2.5 per cent of ammonium bromide, according to the desired intensity of the iridescence, is applied. The final coat consists of a solution of collodion cotton. On the face of it, this process is very difficult to carry out and consumes a great deal of time. Nevertheless it possesses one distinct advantage in being absolutely reliable. In general the practical way of applying the process is to dissolve about 20 grams of gelatine in 100 ccm. of water and to dilute this solution with 100 ccm. of water containing one gram of ammonium bromide. This gelatine solution is then used to coat the object to be treated. Then the latter is dipped in the 1 per cent silver nitrate solution, dried, and finally coated with collodion or a protective varnish. Iridescence is produced by the action of the silver nitrate.

If it is desired to produce real illusory effects on the aforementioned objects, then the essence made from fish scales is added to the gelatine solution, used to give the first coating. The rest of the process follows in the same manner as above. The play of colors is seen for the first time, after the combination of this coat with the first bromide film takes place and may be intensified to any desired degree by the application of other coatings. As can be readily understood, instead of collodion which is really only a protective coating, any other transparent varnish can be used. It may also be mentioned that the iridescent effect can be obtained with the help of opalescent varnish lacquers. These lacquers are especially effective when used as a top coat on gelatine undercoats. The author has also developed methods of making water white phenol resin solutions, which were used to produce the mother of pearl opalescent effects by mixing various salts with the resin solution.

[1]See *Zeits. für Chem. v. Ind. der Koll.*, Vol. 12, pp. 181, 188.

Problem of Preventing Dust Explosions*

Causes and Factors Affecting Dust Explosions and Types of Industrial Plants Affected

By David J. Price

AT the present time the prevention of dust explosions is commanding the earnest attention of engineers of all classes both in the United States and abroad. This is quite natural, since many engineering problems have been developed in the study of dust explosions, their causes and prevention. Before these explosions can be prevented, it is necessary to understand fully their nature and behavior. This means a determination of the various causes and circumstances under which dusts may be ignited; the manner in which the explosion spreads or propagates; the ignition temperature of the various dusts; the pressure that will be developed during the explosion, and also the effectiveness of any methods which may be designed for prevention.

It is not the intention to consider in this article the simple causes that have been established since the study of grain dust explosions was undertaken by the Federal Government. It is well known that disastrous explosions have resulted from the ignition of flammable[1] dusts by matches, open flames, lanterns or torches. The attention of engineers at the present time should rather be directed particularly to the mechanical causes, especially those which occur during the handling of organic materials.

*From *Chemical and Metallurgical Engineering*, Jan. 5, 1921.

[1]The National Fire Protection Association, the National Safety Council and similar oranizations are now using the word "flammable" instead of the old word "inflammable." Some persons have misinterpreted inflammable, thinking of the first two letters of this word as the prefix *in* whose meaning is *not*, as in inactive (not active), or incombustible (not combustible). Flammable is not only a shorter term, but a more definite one, and furthermore is one which cannot be misunderstood. The negative of flammable is non-flammable.

TYPES OF INDUSTRIAL PLANTS

In order to understand the nature and extent of dust explosions it is essential that consideration be given to the kind of industrial plants in which these explosions are occurring.[2] Dust explosions have occurred most frequently in plants where grain or grain products are either milled or handled, such as grain elevators, flour mills, feed and cereal mills and starch factories. Disastrous explosions have occurred also in sugar refineries, cocoa and chocolate plants, candy factories, spice works, wood-working establishments, paper mills and printing plants, shoe factories, fertilizer works, cork-grinding plants, drug and herb works and similar types of industrial plants where dusts are created. Explosions of aluminum and magnesium dusts have also taken place. Many disastrous smut and grain dust explosions have occurred in threshing machines in the Pacific Northwest, while a large number of fires

[2]The study of the cause and prevention of coal dust explosions is being undertaken by the Bureau of Mines, United States Department of the Interior, while the work pertaining to the cause and prevention of dust explosions in industrial plants is being carried on in the Bureau of Chemistry of the Department of Agriculture.

DESTRUCTION OF A GRAIN ELEVATOR IN NEW YORK HARBOR FOLLOWING A DUST EXPLOSION

A SUGAR REFINERY BADLY DAMAGED BY AN EXPLOSION OF SUGAR DUST—TWELVE LIVES LOST

STARCH FACTORY IN IOWA COMPLETELY DESTROYED BY STARCH DUST EXPLOSION. FORTY-THREE LIVES WERE LOST AND $2,000,000 PROPERTY DAMAGE WAS DONE.

GRAIN ELEVATOR, PORT COLBORNE, CANADA, AT ENTRANCE TO WELLAND CANAL, BADLY DAMAGED BY GRAIN DUST EXPLOSION—TEN LIVES LOST

have also occurred in cotton gins during the ginning process.

Since May, 1919, a series of very disastrous explosions have occurred in the United States and Canada, resulting in the death of over eighty-eight persons; injury to a large number, and property damage in excess of $7,000,000. Three of these explosions have occurred in grain elevators, one in a feed mill, one in a starch factory and two in flour mills. In the starch factory explosion forty-three lives were lost and over $3,000,000 damage was done. Fourteen lives were lost in one grain elevator explosion and ten in another, both explosions being very violent and doing extensive damage to property. In an explosion of "aluminum dust"[3] in a Northwestern factory six girls lost their lives and as many others were injured. A recent explosion of "hard rubber" dust in a Michigan plant resulted in the death of eight workmen and has attracted considerable attention.

IGNITION TEMPERATURES OF GASES AND DUSTS

From the experimental work which has already been conducted it appears that a dust explosion is very similar to a gas explosion. Although particles in a dust cloud are larger than the minute molecules in a gas mixture, yet the nature and behavior of a dust explosion appears to be very much the same as a gas explosion. To produce a gas explosion it is necessary that a proper mixture of gas and air and a source of ignition be present. The same condition exists in connection with producing a dust explosion. It is as impossible to produce a "spontaneous" explosion with dust as it is with gas. In both cases the explosive mixture must be ignited by some external source of heat or flame.

In order to obtain some idea as to the relation between dust explosions and gas explosions it will be of interest to note the ignition temperatures of the more common flammable gases in air as determined by Dixon and Coward.[4]

Gas	Ignition Temperature Deg. C.
Carbon monoxide	644 to 658
Hydrogen	580 to 590
Ethylene	542 to 547
Methane	650 to 750
Ethane	520 to 630

A series of experiments was conducted by R. V. Wheeler, chemist attached to the Explosions in Coal Mines Committee of England. In the first series of tests an effort was made to determine the temperature at which the dust would ignite and propagate flame. A second series of tests was conducted to determine the lowest temperature at which ignition could be effected. The following results were obtained:

Kind of Dust	Ignition Temperature, Deg. C.	Temperature of Flame Propagation, Deg.
Dextrine	540	940
Sugar	540	805
Starch	640	960 to 1035
Flour	650	1060
Grain	630	995 to 1050

Wheeler states in his report that sugar and dextrine appeared to be the most flammable of all the dusts, the temperature at which ignition could be effected being 540 deg. C., a temperature well below red heat. It is interesting to contrast this low temperature with the ignition temperatures of the gases given above, from which it will be noted that the ignition temperatures of sugar and dextrine are lower than methane, carbon monoxide and hydrogen, ranging with ethane and ethylene. Most of the remaining dusts have practically the same ignition temperature, 600 to 650 deg., thereby ranging with the other gases.

When the Federal Government began the study of dust explosions attention was directed to a determination of the ignition temperatures of the various dusts and the methods and conditions under which these dusts propagated flame. With the apparatus used in the tests, the following results were obtained:[5]

Kind of Dust	Ignition Temperature Resulting in Propagation
Wheat elevator dust	1295 C. equals 2363 F.
Flour	1265 C. equals 2300 F.
Oat and corn elevator dust	995 C. equals 1821 F.
Oat hull dust	1020 C. equals 1868 F.
Yellow corn dust	1025 C. equals 1877 F.

From the many theories which have been advanced in the effort to explain the action that takes place during the progress of dust explosions, two appear prominently: (1) That

[3]*Chem. and Met. Eng.*, Vol. 23, No. 19, 1920, p. 915.

[4]*Trans. Chem. Soc.*, Vol. 95, p. 517.

[5]Preliminary Report on the Explosibility of Grain Dusts. Co-operative Investigation by Millers Committee, Buffalo, N. Y., under the direction of Dr. George A. Hulett, chief chemist, Bureau of Mines, U. S. Department of the Interior, by David J. Price, engineer in charge, and Harold H. Brown, assistant chemist, Grain-Dust Explosion Investigations, Bureau of Chemistry, U. S. Department of Agriculture. Copies no longer obtainable.

a distillation of flammable gases occurs when the dust becomes heated, resulting in an explosion; and (2) that the explosion is nothing more than a rapid communication of flame or fire from one particle to another, depending to a large degree on the fineness of the dust. That is, the finer the dust and the lower the moisture content the more rapid the propagation and therefore the greater the violence accompanying the explosion. This would seem to establish very definitely a relation between fire and explosion.

In connection with the investigation of a large number of explosions and fires in grain threshing machines in the Pacific Northwest, the Department investigators made the following determinations:[6] In 117 cases observed 95, or about 80 per cent, were sudden, violent explosions, and the remaining 22, or 20 per cent, were merely fires. This would seem to indicate that in the majority of cases the explosions were accompanied by violence, while in the others the fire had not advanced to a point where it assumed the proportion of an explosion.

In the 95 cases referred to it was felt that the explosion might be classified either as sudden and violent, or as slight and muffled in nature. The same phenomenon has developed in connection with dust explosions in industrial plants. In many cases a primary explosion, which is nothing more than a small puff, is followed by fire in which the property is extensively damaged or destroyed. In other cases a series of explosions follows, becoming more violent as it progresses, destroying both life and property. This would seem to indicate very definitely that if the dust is present in the plant to feed the original flame, an explosion follows. In plants where little dust is in suspension and where "good housekeeping" is practiced, the occurrence merely assumes the proportions of a fire and no violent explosion results. Reference is made to this phenomenon at this time to emphasize the fact that a disastrous dust explosion may occur during the course of any fire if sufficient combustible dust is present in the plant to feed the flame and allow it to propagate. The dust that accumulates throughout the plant is thrown into suspension by slight concussion, with the result that the primary "ignition" or explosion develops into a secondary explosion of large proportions.

VELOCITY OF FLAME

Experimental work has been conducted to determine the velocity or rate of flame travel in dust explosions. It is understood that the rate of propagation or flame travel in a gas explosion depends upon two factors: (1) The flammability of the gas, and (2) the amount of gas present. For instance, the explosive limit of methane gas ranges from 5½ to 14.5 per cent,[7] with 9.6 per cent as the most flammable mixture. With this latter percentage the rate of flame travel is the most rapid and the explosion most violent. The rate of flame travel in dust explosions depends also on (1) the flammability of the dust, and (2) the amount of dust in suspension. In some of the early reports of the Bureau of Mines it is stated that the average velocity of flame in coal dust explosions is 2,270 ft. per second. British investigators report 2,114 ft. per second, while in French experiments 3,300 ft. per second has been obtained.

The maximum velocity of propagation of flame in many gaseous mixtures has been determined with accuracy. The following results have been obtained:

Gaseous Mixtures	Velocity, Feet per Second
Hydrogen, $2H_2 + O_2$	9,250
Ethane, $C_2H_4 + 3O_2$	7,724
Methane, $CH_4 + 2O_2$	7,616
Carbon monoxide, $2CO + C_2$	5,510

The velocity of propagation in explosions through most gas mixtures is more rapid than through most dust clouds, although in a few cases it has been found that the velocity of flame propagation in coal dust explosions has exceeded the maximum for certain gases. In only two tests has any attempt been made to measure the velocity of propagation of the flame in clouds of materials other than coal dust. One indicated that the velocity through a cloud of wheat flour dust was practically the same as through coal dust; the other that the propagation through a cloud of powdered starch was several times as rapid as through coal dust. The results, however, cannot be considered to be conclusive.

PRESSURES DEVELOPED BY DUST EXPLOSIONS

In connection with the determination of the ignition temperatures and the relative ease of flame propagation of dusts an effort has been made to determine the pressures developed during the progress of the explosion. In the large-scale tests that have been conducted the Bureau of Mines reports a pressure of 103 lb. per sq. in. with coal dust. British investigators report pressures ranging from 100 to 120 lb. per sq. in. Taffanel, a French investigator, reports pressures of 227 to 270 lb. per sq. in. He states that in one test at the steel gallery an established pressure strength of 227 to 270 lb. per sq. in. was maintained and that pieces of steel were thrown up a distance of 150 m., or 472 ft.

Much work to determine the relative flammability of the various dusts has been done by both the Bureau of Mines and the Bureau of Chemistry. After a series of extensive experiments the following results, based on the use of 75 mg. of dust in the standard laboratory apparatus, were obtained:[8]

Kind of Dust	Pressure Generated Lb. per Sq. In.
Lycopodium	17.5
Wheat smut dust	15.9
Yellow corn	15.2
Dextrine	14.6
Tanbark	13.3
Wheat elevator dust	13.0
Wood dust	12.8
Corn starch	12.7
Sugar	12.2
Potato flour	11.7
Fertilizer	10.5
Coal (Pittsburgh)	10.1
Cocoa	9.1
Sulphur	8.8
Cork	7.4

From these results it might be concluded that the grain dusts are more flammable than Pittsburgh standard coal dust. This has been confirmed by large-scale tests which indicate that flame propagates through a cloud of grain dust more easily and with a more violent explosion than through a corresponding amount of coal dust.

In very recent tests conducted in coöperation with the Bureau of Mines in the steel galleries at Bruceton, Pa., it was found that flour and coal dusts acted similarly. Starch dust propagated more rapidly, produced higher pressures, and did a great deal of damage to the steel galleries used in the tests.

It has already been stated that dust must be present in suspension in proper proportions before an explosion can occur. Efforts are being made in the experimental work to establish these proportions, as has already been done in connection with the gas mixtures. In some of the tests conducted results were obtained when one-twentieth grain, or 0.00176 oz., of dust was put in suspension in 1,400 cc., or 85.36 cu. in., of air. To obtain the same proportion of dust in air and render the mixture as flammable as that used in the laboratory test it would be necessary to have only 10 lb. of the dust in a closed room containing 4,446 cu. ft., or a room 10 x 30 x 15 ft.

The first dust explosion to attract attention in this country

[6]U. S. Department of Agriculture, Bulletin 379, p. 5.

[7]U. S. Bureau of Mines Technical Paper 150, p. 6.

[8]*Journal of Industrial and Engineering Chemistry*, Vol. 9, No. 3, p. 269.

occurred at Minneapolis in 1878. Professors Peck and Peckham of the University of Minnesota conducted experimental work in the investigation which followed the explosion. In this investigation it was found that by blowing 2 oz. of dust upon an open flame in a box containing 2 cu. ft. of air sufficient pressure was developed to lift two men standing on the cover.[9] This would mean diffusion at the rate of 1 oz. of dust to 1 cu. ft. of air space. Their report states that a sack of flour and 4,000 cu. ft. of air will generate force enough to throw 2,500 tons 100 ft. high.

The Bureau of Mines reports that explosions could be produced when only 0.032 oz. of coal dust was suspended in 1 cu. ft. of air, or 1 lb. in 500 cu. ft. It was found in order to produce complete combustion all the oxygen in 1 cu. ft. of air was required to burn 0.123 oz. of the dust used.

In the French experiments conducted by Taffanel an instance is cited in which the low weight of 0.023 oz. of dust per cu. ft. of space was sufficient to produce an ignition.

Experimental work is now in progress to determine definitely the smallest amount of dust in suspension per unit area through which an explosion can propagate.

RELATION OF HUMIDITY TO EXPLOSION FREQUENCY

The relation of humidity to the frequency of dust explosions has been markedly noticeable in the investigational work. This is especially true in connection with explosions where static electricity has appeared as a probable cause. In the large number of thresher explosions in the Pacific Northwest, which comprises the inter-mountain territory between the Cascade and Rocky Mountain ranges, it was found that in 128 cases 86 explosions, or 70 per cent of the total, occurred between the hours of 1 and 7 P. M., when the humidity was extremely low. The range of humidity was usually from 6 to 17 per cent. These explosions have occurred in grain separators during the threshing of wheat containing smut dust. In 112 explosions from 1 to 35 per cent of the heads of wheat being threshed were smutted. In 108 cases the average smut percentage was 15.

WIND POWER*

On behalf of the Zionist Organization, Dr. Ing. M. Mayersohn has recently studied the wind-power problem with special regard to installations in Palestine. In his dissertation, presented to the Berlin Technical High School, he has collected a great deal of useful information on the types of wind mills used in Denmark, Germany and Holland, on experience gained with them and on the design of new installations. He makes out a better case for windmills than might be expected. He gives information on 477 installations—not ordinary grain mills. Of the 415 German mills of those tables 87 per cent had worked very satisfactorily for periods of up to eighteen years. In Denmark, the utilization of wind power has been much stimulated during the war; in several instances small communities are coöperating in supplying the local electricity works with from 20 per cent to 50 per cent of the power needed.

The favorite new wind motors for this purpose are Agricco motors, made by the firm of Hans L. Larsen, and known hence also as the Hansell motors. The Agricco wheel consists of five wings of the propeller type, made of sheet-iron, each wing turning against the action of a spring about its radial arm, to the one side of which it is attached. The older types common in Denmark are the Paul La Cour wheel—four or six arms set cross-ways with vanes of the Venetian-blind type—and the Sörensen cone motor. The six wings of this latter motor would, if placed together, make up the surface of a cone of a very obtuse apex angle; each wing is built up of curved cross-vanes. Sörensen motors have been built up to 27 m. (88 ft.) in diameter for 50 hp., but they are not so efficient as the Agricco. The old-fashioned wind roses, large wheels consisting of many radial vanes of wood, are still built in Denmark; most of the vanes we have mentioned are made of galvanized iron. More common in general are the wind turbines of the American construction, up to 5 m. in diameter, and the German wind turbines of the Herkules type, made in diameters of 15 m. (50 ft.) and even 30 m.

Some of the 477 windmills which Mayersohn inspected or about which he inquired had done thirty-five years' duty. La Cour's Askov mill works still after twenty-three years without having ever been repaired. Only six total wrecks were reported. Repairs are not infrequent, especially in some parts of Germany, where the peasants take the notice too literally that the mills require little attendance. Grease was, moreover, very scarce during the war. Trouble had also arisen because the man in charge, finding that the mill could deal with heavy loads, increased the load until the wheel could not turn and became a prey to the wind. In other cases the wheel would not come to rest, causing overflow and other disturbances. Most of the plants serve for pumping, irrigation or drainage; a few mills drive workshops directly, or propel electric machinery with or without accumulator batteries.

Small agricultural machinery can generally be fitted for wind power, without difficulty. For installations of more than moderate dimensions, however, the project should be studied as carefully as with water power. A wind velocity of 2 m. per second, which can generally be relied upon in Northern Central Europe, is sufficient to start some types of wheels, though the La Cour wheels require speeds of 5 m. But the designer has to inquire into the maxima and minima as well as into the average values. A calm of a day or two is a serious feature; longer calm periods during windy days are also to be reckoned with, and in recognition of the utility of wind power the German Meteorological Office has recently supplemented its reports so that the wind velocity can be traced through its diurnal period. Where calm days must be allowed for, the storage capacity of the plant has to be increased. At Haifa, on the coast of Northern Palestine, a good wind is blowing all the summer months, from May to October, but there are calm days in these two months, when the season changes and when irrigation is still necessary. The meteorological observations taken by the German settlers there before the war show that in 1908 there was no wind on May 17 and 18, and again on May 20 and 21, and on May 26 and May 29. To meet this trouble it is recommended that the storage capacity should be increased from two days to at least three days.

DIRECT CURRENT CONVERSION

In the French press there appeared a description of an apparatus whose object is the simplification of methods whereby direct current can be converted from one voltage to another. It is manufactured by the Société Romain Bon of Liége and is briefly described by *Electrician* (London), as follows:

It consists of what is essentially a direct current generator, but with a fixed armature and a rotating field. Instead, however, of the usual arrangement of armature windings, what are in effect a number of series transformers are used, the terminals of which are connected to a commutator from which current can be collected by a system of revolving brushes. This arrangement in combination with the revolving field and an elliptical air gap gives an equipment whereby any desired conversion can be realized by increasing or decreasing the number of ampere turns in the stationary coils. The makers point out that as the general conditions resemble those of a static transformer a minimum of iron and copper are required, and that there are no crossing leads at different potentials, thus facilitating insulation and reducing the risk of short circuit. Commutation is said to present no difficulty, though the usual design is modified by replacing the parallel bars with an arrangement of staggered contacts. Nevertheless, as the biggest machine that has so far been built is 1 kw., it is too early to be definite on this point.

[9] *Chemical Engineer,* March, April, May, 1908.

*From *Engineering,* (London) Dec. 10, 1920, p. 769.

Thermal Conductivity of Building Materials*

Experiments Undertaken to Determine the Heat Losses of Various Structures

By C. Schroeder

THE question of conservation of heat in a building presents far more difficulties than some other problems of construction. Usually persons considering this subject content themselves with the somewhat vague declaration that insulating of "warm" walls should be employed. An opinion which rests rather upon the sense of feeling and upon "non-controllable" experience than upon exact experimental investigations, but the question is undoubtedly of peculiar and pressing importance today because of the scarcity and dearness of fuel. Obviously the more pervious to heat a wall is the greater the waste of fuel when the space enclosed by it is to be kept at a hygienic degree of temperature. . . . It is not until comparatively recent years that an effort has been made to determine these questions by scientific methods. Some time before the beginning of the Great War a start was made in this matter by the Laboratory for Technical Physics connected with the Technical High School in Munich. Assistance was lent by the coöperation of the Munich "Institute for the Study of the Economics of Heat," which was founded by industrial circles in October, 1918.

The investigations made by these bodies were based upon the following well-known facts. A source of heat of a constant strength (a stove, radiator, etc.) was used. By means of this source of heat the air in the room is first warm and then the walls which enclose the room become heated and finally a portion of the heat which has pentrated the walls passes out into the surrounding atmosphere. There finally occurs a state of equilibrium in this process, which can be recognized by the fact that when this state is reached the same amount of heat is given off by the wall into the outer air as has been received by the inner side of the wall. . . . This passage of heat through the wall is comparable to the flowing of a fluid. The obstacles met by a stream of water can be overcome only when a certain amount of pressure or a corresponding difference in height is present, and such obstacles may be compared to the resistances (which vary according to the material) encountered by the current of heat and which the latter can overcome only by a change of temperature corresponding to the resistant object in question. Just as the water can flow more rapidly over a smooth surface so the denser the body to be penetrated the less resistance encountered by the current of heat; just as a gutter with uneven and rough walls hinders the flow of water, a loose, light, air filled material checks the flow of the current of heat.

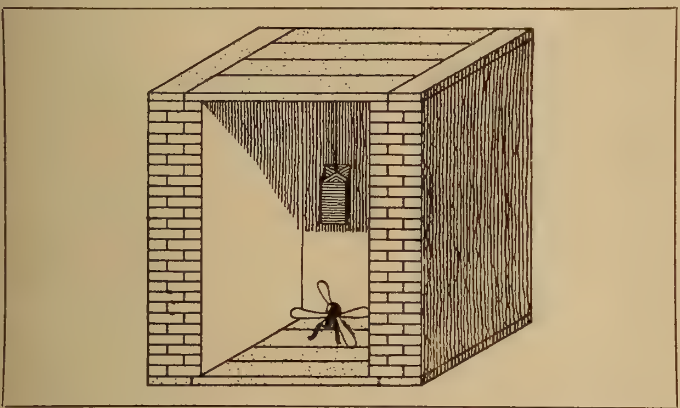


FIG. 1. EXPERIMENTAL COTTAGE FOR TESTING THE CONDUCTIVITY OF HEAT IN BUILDING MATERIALS

The hot air from the electric heater is distributed evenly by the electric fan

*Translated for the *Scientific American Monthly* from *Die Umshau* (Frankfurt), October 16, 1920.

In analogy to the laws of fluid bodies it is found that within like intervals of time the amount of the heat transmitted increases in the same ratio as the area of the surface and as the difference of temperature between the two sides of the wall, while it decreases, on the contrary, in proportion to the thickness of the wall; finally, it is in harmony with a special factor, namely, the degree of conductivity of heat for the given material. This magnitude, known as the thermal conductivity number, gives the units of heat which pass through the surface unit of the wall (1 sq. m.) in the unit of time (1 hour) when there is a difference of 1° C. between the two surfaces of a wall 1 meter thick.

These thermal conductivity figures have been determined by careful experiments with various building and insulating materials, such as common tile or brick, as also the porous and hollow variety, slag, natural stone, mortar, wood, gypsum, sheets of cork, and of peat fiber, etc. These materials were prepared in sheets having a surface extent of about ¼ of a square meter and were warmed on one side by exposure to an electric source of heat. Special care was taken to have all the heat produced pass through the material to be tested. The thermal conductivity figure was then determined after the stage of permanency was attained, by a calculation involving the factors of the given amount of heat, the surface, and the thickness of the material. These figures having been obtained it is easy to calculate the quantity of heat transmitted through any given wall composed of one or more of these substances. For example, the following figures were obtained for various walls:

1.44 cal. in a brick wall of a thickness of 1½ bricks (this may be regarded as the normal wall for dwelling houses);

1.66 cal. in a gravel cement wall, 40 cm. thick;

1.87 cal. in a limestone wall, 1½ stones thick;

2.4 cal. in a wall 50 cm. thick built of quarry stones.

On the other hand a wall made of hollow tiles, one brick thick gave the figures 1.3 calories, while still more advantageous was a well plastered wall only 1 brick thick of Rhenish porous stone in which the loss of heat was reduced to 0.77 calories; not quite so good but still excellent was a wall of the same thickness made of furnace slag which allowed the passage of about 1.15 calories.

The higher prices and scarcity of building materials have naturally led to inferior construction with a corresponding increase in the amount of heat transmitted through these poorer and thinner walls. This can be partly compensated, however, by the use of special insulating materials, such as sheets of cork, peat fiber, etc. It has been proven in fact, that this distribution of solidity and insulation among two different materials give especially good results. Thus we find that the loss of heat in a brick wall covered with a layer of insulating material 3 cm. thick reduces the loss of heat as follows:

From 1.44 to 0.78 calories in a wall 1½ bricks thick
From 2.10 to 0.92 calories in a wall 1 brick thick
From 3.85 to 1.17 calories in a wall ½ brick thick

A great many new methods of building have sprung up since the war; these mostly employ gravel cement or slag cement in combination with layers of air or hollow spaces filled with some insulating material; it is impossible to assign fixed values to the heat loss in such cases, since the thermal conductivity of cement varies greatly according to its composition, method of mixture, and density. The heat loss of a structure built with walls consisting of a 6 cm. gravel cement layer, a 12 cm. layer of air, and a 6 cm. layer of slag cement, is estimated at approximately 2 calories, but when the air space is filled with slag this value is reduced in

the case of a brick wall 38 cm. thick. Prepared cement blocks which are frequently divided by air layers show a heat loss of 1.2 calories in the most favorable cases. Houses made of wood, or of wood combined with unburnt brick or slag blocks when they contain well distributed air spaces, vary in their heat law from 1.1 to 1.6 calories.

Testing Heat-loss in Experimental Houses.—For the purpose of testing heat-loss in such forms of construction under conditions approximating those encountered in actual practice, small experimental houses were built with side walls, 2 sq. meters in area (Fig. 1). These were set up in a large laboratory in order to avoid difficulties and complications due to variations in the weather outdoors. Definite forms of structure was chosen for the walls: A brick wall 1½ bricks thick, a concrete wall composed of gravel cement and slag cement, wooden walls and roofs; the floors and ceilings were constructed of an insulating material having a known thermal conductivity. The source of the heat—an electrically heated body, was placed inside each of these little houses near a fan whose purpose was to distribute the heated air evenly. The method of measuring the loss of heat was the same as in the first experiment. In this manner it was possible to make an immediate measurement of the amount of heat transmitted

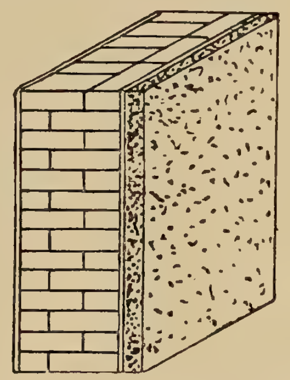


FIG. 2. WALL SHOWING AUXILIARY WALL OF KNOWN THERMAL CONDUCTIVITY IN FRONT OF IT

The heat loss in the wall being tested is found by measuring the temperature on each side of the two walls

through the wall under test. It was also possible to determine the effects produced by outside influences such as the amount and distribution of humidity, etc. The results obtained agreed admirably with the individual values previously secured. Thus, for example, the heat-loss from the brick wall 1½ bricks thick was found to be 1.43 calories. (Figures similar to those obtained by theoretical calculation.) A framework structure which was lined with boards on both sides underlaid by plaster covered boards proved excellent, with a loss of only 0.8 calories; without the underlay of plaster covered boards the heat loss amounted to 1.2 calories. In a structure composed of hollow cement blocks there was a heat loss of 2.1 calories which indicates that this form of building is of doubtful value.

In order to complete the experiments by a study of the influence exerted by *location and climate* a simple experiment was devised by means of which the conditions of the heat conductivity in the finished building can be tested in any given instance. As shown in Fig. 2, this method consists in placing in front of the wall to be tested an extra wall having a known thermal conductivity. The room is then heated by any desired source of heat and kept at as even a temperature as possible. The warmth thus produced must pass through the auxiliary wall before reaching the wall of the room. In each of the two walls a current resistance makes its appearance and, as explained, in the earlier portion of this article, this resistance can be overcome in the case of a given amount of heat only by a given difference of temperature. Consequently, the resistances exhibited to the flow of the heat correspond to the differences of temperature. Since the resistance to heat conduction of the auxiliary wall is a known quantity, it is only necessary to find the temperatures upon each side of the auxiliary wall and each side of the wall to be tested, in order to discover the amount of resistance to the conduction of heat exhibited by the latter. A simple calculation enables us to determine the quantity of heat loss from the amount of resistance displayed.

The present conditions obtaining in Germany as to supplies of coal . . . indicate the great economic importance of this question. It is to be hoped consequently that the Department of Buildings and Construction which has hitherto been concerned chiefly with the safety from fire and the solidity of buildings, will require that proper care be taken to secure the proper amount of protection against heat loss in their construction. In their own interest persons erecting buildings should demand of their architects the greatest attention to the securing of economy of fuel, while architects themselves must be advised of the necessity of enlarging their scientific equipment for the practice of their profession by a study of the technology of economy of heat.

RESEARCH IN WOOD FOR THE BUILDING INDUSTRY

For generations the proper size of timbers to use in wood buildings was a matter of custom. Now higher working stresses are permitted by building codes and it is possible to design more economical buildings. This is the result of increasing knowledge of the strength properties of wood. Much of the credit for making available this essential information belongs to the Forest Products Laboratory at Madison, Wisconsin. Considering its relatively meager appropriations from year to year and the financial uncertainties under which it labors, its accomplishments have been great. But the needs of further knowledge in the use of structural timbers are almost unlimited.

How shall built-up beams and columns be designed, and what are these conditions under which their use is desirable? How can structural timbers be preserved from decay and the attacks of borers? What influence have defects on the strength of columns? What stresses should be used in wood girders and trusses of 50 to 70 foot span such as are used in garages? What do we know of the strength of fastenings and joints? Has fireproofing and slow-burning construction been fully developed? What of shrinkage and the better seasoning of wood? And with carefully worked out grading rules and consequent higher working stresses why cannot the cost of wood buildings be materially reduced? The Forest Products Laboratory is seeking to solve some of these problems, but in order to do so, it needs the support of industries which will benefit by its results.

DISINTEGRATION OF ROOFING TILE

According to J. Scott, who writes in *The British Clay Worker*, 29, 138-140 (1920), roofing tile sometimes disintegrates owing to a fungous growth, a type known as mucor racemose being especially destructive. Rain and dust settle in the pores of the tile and this becomes a foundation for the spores. A net work running through the pores of the tile is formed as the spores grow and in a few days thread-like spore-bearing stalks are sent up and these soon scatter a new lot of spores. The fungus obtains its food partly from the dust and partly from the tile and the stalks are hollow and filled with a sap traveling upward. The points of these stalks or threads yield ferments which enable them to soften and split off small particles from the tile. During the process volatile mineral matter required for the fungus is drawn from the tile leaving it more susceptible to the destructive action of thawing and freezing. Thus this natural chemical process proceeds, although slowly. Lichen, which very often covers roofing tile, is not destructive to it since it obtains its nourishment from the air.

The Welding Arc*

Is the Metal Transmitted Chiefly as a Spray or as a Vapor?

By A. W. Slocum

Professor of Physics, University of Vermont

DURING the summer of 1918 the writer was associated with the Welding Research Council. During that period he made a careful study of the Welding Arc.

Transmission of the metal in the form of vapor appeared to be the most probable hypothesis. This part of the phenomena, however, is so marked by the unavoidable spraying and spluttering of the electrode and plate that many have considered this as the essential part of the phenomena. This point of view is ably presented by Prof. R. G. Hudson of the Massachusetts Institute of Technology in his article on a theory of metallic arc welding published in the first issue of the *Journal of the American Welding Society* and republished in the Scientific American Monthly for March, 1920.

Professor Hudson says: "It would appear from the observed facts that the metal deposited during metallic arc welding is transmitted in part at least in the form of minute particles which are projected from the electrode globule by the internal expansion of some vapor, possibly carbon monoxide."

He also says: "Under the circumstances, it may be seen that the melting of the iron is delayed by the heat absorbed by the other constituents of the electrode, and that this fact together with the limited time of application of high temperature disproves the possibility that the iron is completely vaporized in the welding process."

Stated in such terms, Professor Hudson's conclusions are entirely correct. The metal is transmitted *in part* from the electrode to the plate and from the plate in all directions in the form of spray or globules. And if it is transmitted in part as spray, it is evident that it cannot be *wholly* transmitted as vapor. The question whether the chief element in the phenomenon is vaporization or gaseous propulsion is, however, still a live one. The writer has little doubt that transfer in the form of vapor will ultimately be accepted as the more probable hypothesis.

It is not a wholly new hypothesis. Frequent reference to a kind of vapor formation is made in the literature of the common arc. Such references are generally made in a suggestive rather than positive manner, but the phenomenon of the common arc is more complicated than that of the welding arc. In the common arc the vapor is not produced so rapidly as to sweep the air entirely out of the space between the electrodes. In this case the vapor which is formed from one of the electrodes largely returns and condenses on the electrode from which it comes. This phenomenon can be clearly seen with a microscope of about twenty magnifying power used to view the behavior of a small current arc. Small condensed globules of microscopic size can be seen to emerge from the core of the arc and fly in curved paths toward the respective electrodes from which they came. Some of these particles escape into the air borne along by the air currents. Some return to the electrode at a distance from the spot on which the arc is playing and there deposit as a yellow dust. Some return to the electrode close to the spot from which the arc plays and form a beautiful orange colored coral like growth. The orange deposit is magnetic, the yellow powder is not magnetic. These growths and powder deposits for arcs with different metals are described by Professor Duffield, *Phil. Mag.*, 1918.

When the current strength becomes sufficiently large to sweep the air entirely away and form a vapor core from electrode to electrode we have the "hissing" or welding arc.

It is true that the hissing arc is generally referred to as being due to the action of oxygen getting at the crater, largely on the basis of the careful experiments of Mrs. Herta Ayrton. She showed beyond doubt that under certain conditions the addition of oxygen would cause a silent arc to become a hissing arc. She also found that a stream of hydrogen sent into an arc which was surrounded by atmospheric oxygen would cause the arc to become a hissing arc, while hydrogen sent into an arc which was surrounded by nitrogen would not cause the arc to hiss. She naturally associated hissing with the presence of oxygen, but it is clear that it might just as well be associated with the increased heating effect of oxidation and the more rapid formation of vapor to form the vapor core from electrode to electrode.

That the conditions in the arc are favorable to vapor formation is clearly shown by the results of the measurements of the electrode tips by Hagenbach and Langbein. The following paragraph is quoted from *Science Abstracts* (Section A, Physics), April, 1919:

"*Temperature of the Electrodes in the Arc.* A. Hagenbach and K. Langbein (Archives des Sciences 1. (Sec. 5), pp. 48-54, Jan.-Feb., 1919). For current densities not too small the anodes of metallic arcs (silver, copper, iron, nickel and tungsten) are heated at the tip by the current up to the temperature of ebullition, while the cathodes are heated less. If the end of the cathode is strongly oxidized and forms an oxide with a high temperature of ebullition, aluminum, zinc and magnesium) the temperature rises still higher, probably up to the temperature of ebullition of the metallic oxide. If oxidation is prevented by using an atmosphere of nitrogen, the temperature is lowered to the ebullition temperature of the metal. The temperature of the cathode is found to be the same as that of the anode in the case where metallic oxides are formed."

In the electric arc the heat that raises the temperature of the electrode tips is produced and delivered directly on the surface of the tips. The heat is produced in accordance with the law; watts equal the product of amperes (current strength) and volts (electrode fall). To liken the process to the heating of the surface of a bullet by the heat produced in the burning powder is totally to disregard the peculiarity of electrical activity.

The secret of the electrical activity of the arc lies in the electrode fall. To attempt to describe its action is a matter of extreme delicacy and great difficulty.

It is directly associated with the electric force necessary to produce thermions from the tips in sufficient quantity for the current strength. This electric force is conditioned by the temperature of the electrode tips, is affected by the presence of oxides, depends upon the material in the surface layer of the tip, is of different magnitude at the anode from that at the cathode and the force at one electrode is affected by the freedom of thermionic liberation at the other electrode. It is the intricate interrelationship of these factors that makes the arc a difficult phenomenon to examine experimentally, and also the reason why we find so much misguiding information in the assumed results of experiments. The one factor which has probably needed the closest attention, the actual state of temperature of the surface layers of the tips, has seldom received consideration. Before the days of the tungsten filament, and thermionic amplifiers and rectifiers, the importance of the temperature was not sufficiently appreciated.

For the purpose of considering the electric activity of the arc, let us take a low current arc between two welding wire electrodes ⅛ inch in diameter, and then increasing the current by steps, consider the changes that occur with each step.

*From *The Welding Engineer,* Jan., 1921.

When the arc is first struck, the electrode tips are cold, the electrode fall is very large, heat is added to the surface of the tip at a rate proportional to the product of the current strength and the electrode fall, the temperature of the tip rises very rapidly, and the electrode fall diminishes with corresponding rapidity. As the temperature rises, the conduction and radiation of heat away from the surface of the tip increases. There comes a time when the heat produced in the surface just balances the heat conducted and radiated away.

However small the current, so long as it is large enough to maintain an arc, this stage of equilibrium is not reached till the temperature has risen considerably above the melting point of the electrode, and examination with a microscope shows that the surface is vaporizing with considerable rapidity though the greater part of the vapor returns as condensed fine globules to the electrode from which it comes. When the equilibrium between the heat produced and the heat conducted and radiated away has become established, the arc burns steadily so long as the temperature of the surface of the tips, the material in the surface of the tips, and the current strength remains unchanged. A voltmeter joined to the electrodes maintains a constant reading.

If, now, we increase the current, we increase the rate of heat supply. This increases the temperature of the tips and this in turn reduces the electrode fall. Soon the equilibrium stage is reached with the electrodes at a higher temperature than in the first case, lower electrode falls and a smaller reading of the voltmeter across the arc.

When we increase the current to about 8 or 9 amperes, the surface of the anode reaches the boiling point, the electrodes splutter and molten drops fall from the tips. Thus it takes 8 or 9 amperes for a ⅛ inch electrode to supply the heat conducted and radiated away when the temperature of the tip is at the boiling point.

With a current in excess of about 10 amperes, an arc between two welding wire electrodes of ⅛ inch diameter blows up with excessive spluttering. With a ⅛ inch welding wire as one electrode and a plate to be welded for the other electrode, the arc burns without too excessive spluttering with 150 or even 175 amperes flowing.

This leads us to an interesting question which pertains to the welding arc alone. What influence on the welding wire can the plate have to increase the current capacity of the wire from 10 to 150 amperes? Alternating current behaves in this respect as direct current. The phenomenon is then one that depends upon the square or some even power of the current. This consideration limits the phenomenon to one of heat effect. We have, therefore, only two hypotheses to consider: the heat effect in the propulsive expansion or formation of gases, and the heat effect in the production of vapor of the material of the surface of the tip.

For the propulsive expansion or chemical formation of propulsive gases in the interior of the electrode, the heat must be conducted inward from the surface to the interior of the electrode. It is difficult to see how the presence of the plate as opposing electrode can affect this rate of conduction inward so as to reduce it to 1/15 of its value when another wire instead of the plate is the opposing electrode. On the hypothesis of the boiling from the surface of the electrode, it is easy to see that the presence of the plate will produce precisely such a result. Not only this, but it is also easy to see how too strong a current produces a cutting arc rather than a welding arc.

When the vapor formation becomes sufficiently rapid to maintain a tube of vapor from electrode to electrode from which the air is completely expelled, then the arc is behaving precisely like a steam heating plant. The boiling of the surface of the electrode into vapor absorbs latent heat. The condensation of the vapor on the welding plate sets free the latent heat to be conducted away by the plate. The vapor condensing on the plate raises its temperature to the boiling point and we then have the plate in condition for its maximum rate of heat conductance and the voltage drop across the arc at its lowest possible value. Further increase of current strength has no effect upon the voltmeter reading across the arc so long as the material of the surface layers of the tip and plate remain unchanged, but it does begin to boil away the surface of the plate, boiling faster and faster as the current gets stronger and stronger and, in some cases, forming a blast of vapor strong enough to cause a deposit of material at a distance of one or two inches from the spot on which the arc is playing and a still stronger current cuts a hole in the plate immediately under the arc.

On the vapor hypothesis, so long as the current strength is suitable for welding, the amount of metal deposited is proportional to the excess of current above that necessary to keep the temperature of the electrode tip at its boiling point.

On the vapor hypothesis, the maximum current that can be advantageously used in a given case is limited by the heat conductance of the welding plate.

On the vapor hypothesis, the rule is suggested of choosing a current strength suited to the maximum heat conductance of the plate, and use the smallest wire electrode that will handle the current.

In the writer's limited experience with welding during the summer of 1918, these rules seemed to be justified, though often other factors such as an unusual amount of spluttering of the electrode appeared to mask them.

The vapor hypothesis or the gaseous propulsive hypothesis alone cannot furnish a complete theory of the arc behavior. For this purpose, we need a study of the electrode falls and such a study takes us beyond the field of welding.

It is, however, very important for welders to note some of the peculiarities of the arc behavior and the electrode falls.

The arc consists of two electric streams flowing in opposite directions. Increase the intensity of one of the streams and for a given current strength, the other stream diminishes in intensity. Interrupt either stream and the arc goes out.

In very low current arcs, 1/10 ampere or less, the temperatures of the tips are relatively low, and the cathode fall is higher than the anode fall, and the cathode surface becomes hotter than the anode surface. In the case of currents above about one ampere, this is reversed and the temperature of the anode becomes hotter than that of the cathode.

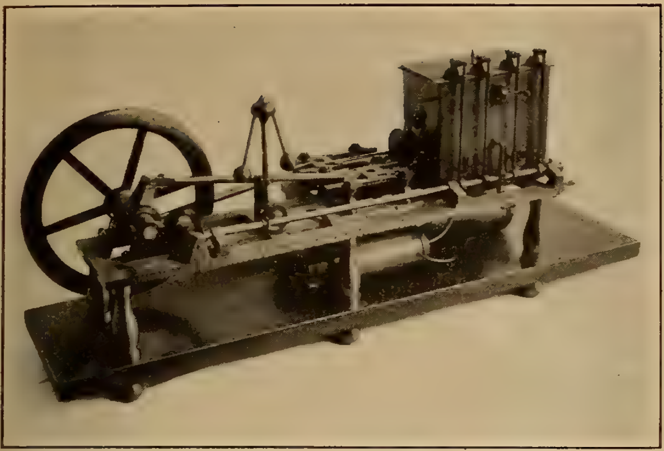
It is easier to start an arc from a cold spot on an anode than from a cold spot on the cathode. The arc is stable with one cathode and two anodes, but it is unstable with one anode and two cathodes. These are the reasons why the wire should be made the cathode in welding. The arc creeps along the cold plate better when it is made the anode.

In conclusion, it seems apparent that the vapor hypothesis of metal transfer deserves the careful consideration of experimenters with the welding arc, that the formation of propulsive gases or vapors of constituents of lower boiling points deserves careful study for their proper control, and that the interpretation of experimental results needs a careful application of the principles of heat, electricity and chemistry. Until we are able to apply these principles simultaneously and harmoniously, we cannot have a satisfactory theory of the welding arc.

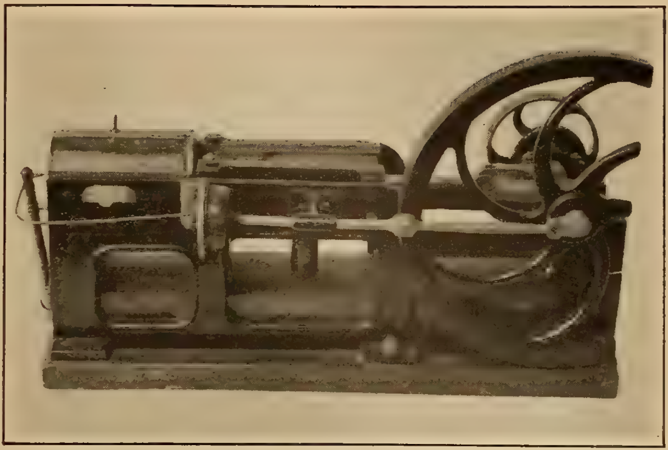
FUEL OIL FROM MAIZE

The germ of this cereal contains approximately 12½ per cent of oil and a special process involving heating with petrol has been developed for its extraction.

It is considered an important one in Serbia and Roumania, where large quantities of maize are available, as, owing to the present scarcity of natural fat, the oil is used for the preparation of fatty substitutes and commands a remunerative price. A factory in Belgrade produces half a ton of oil daily, and other factories are being built. The oil is not suitable for lubrication on account of its resinous nature, but is a good fuel oil.—G. Goldberg, *Feuerungstechnik*, Sept. 1, 1920. Abstracted by *The Technical Review*.



INTERNAL COMBUSTION INVENTED BY PERRY, 1846
The fuel used was the vapor of spirits of turpentine fed by compressed air



OIL ENGINE INVENTED BY ERRANI AND ANDERS, 1873
The first internal combustion engine for which oil was the stipulated fuel

Ancestors of the Liberty Motor

Origin and Development of the Internal Combustion Engine

By Carl W. Mitman
Curator of the U. S. National Museum

Illustrations from Collections in the Department of Arts and Industries, U. S. National Museum

THE earliest internal combustion engine was the gun and assuming that the gun originated with the invention of gunpowder, which has been known in the East from times of dimmest antiquity, it may be inferred that the Liberty motor has quite a pedigree. The use of gunpowder, however, as a means of obtaining mechanical power is of comparatively recent date, such experiments having been made during the latter part of the 17th century by Hautefeuille, Huygens and Papin. Huygens in 1678-1679 exploded a charge of gunpowder in the bottom of a vertical cylinder. The greater part of the air and of the gaseous products were expelled through non-return valves, but the remaining gases, in cooling, produced a partial vacuum below a piston which then descended owing to the atmospheric pressure on the outside and in so doing did work by means of a cord over a pulley.

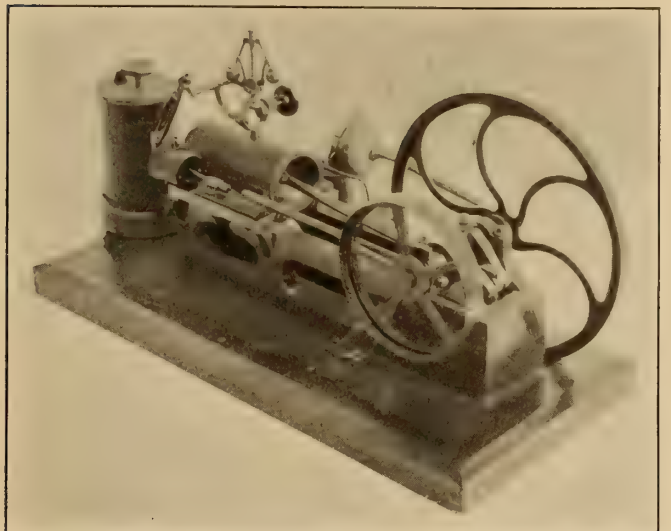
A period of over a hundred years ensued before any further experiments were made utilizing the explosion of inflammable gases. In 1794 an English inventor, R. Street, secured a patent, No. 1983, which involved the vaporizing of spirits of turpentine on a heated metal surface, mixing the vapor thus produced with air in a cylinder, firing the mixture by an outside flame, and driving a piston by the explosion produced. Another fifty years passed when in 1844, one Stuart Perry, of New York, procured a United States patent for "An engine to be operated by the explosive mixtures of inflammable gases or vapors." Two years later a second patent, No. 4800, was granted to Perry for improvements made on the original engine which were embodied in a model submitted at the time of the request for a patent, and which is illustrated here. The rectangular box to the right is a metal tank filled with water and containing the cylinder and a retort in which gas is generated. (Although the patent claimed the use of any inflammable gas or vapor, the inventor vaporized spirits of turpentine.) The cylindrical tanks beneath the engine bed contain air under pressure, filled at first by a hand pump but, after the engine is in motion, by a pump operated by the engine, a portion of which may be seen on the far side of the machine. To operate the engine, it is first necessary to heat the water in the tank by some outside means, in order to vaporize the turpentine. Gas having been generated, the extraneous supply of heat is removed and air from the tanks is admitted into a valve-box located above the retort. Through a slide valve some of this air enters the retort, is mixed with the gas, and exits through suitable apertures to passages leading to opposite ends of the cylinder. The admission of the gas to the cylinder through these intakes is controlled by valves operated by rods (to be seen on the outside of the tank) which in turn are operated by appropriate cams on a shaft receiving motion from the crankshaft. The two inside rods control the exhaust valves, the exhaust being in the under side of the cylinder.

The opening of an intake valve permits the gas to pass along the intake passage to the cylinder. At one point in its travel the gas passes over a hot platinum cup, previously heated by the burning of a portion of the gas obtained through a by-pass from the valve-box. The red-hot platinum ignites the gas and the resultant expansion forces the piston to the opposite end of the cylinder. Upon reaching the end of the stroke, the intake valve at this end of the cylinder opens, admits gas which is similarly ignited and forces the piston back. Such is the cycle. The water in the tank serves a variety of purposes; it keeps the engine cylinder sufficiently cool for efficient operation; its temperature, however, is sufficiently high to vaporize the turpentine; and it lubricates the piston rod and prevents it from being overheated. Another interesting feature of this engine was the firing of the charge of gas by heated platinum rather than a naked flame as practiced by earlier inventors.

Nothing startling came of this engine and another period of 30 years passed before the next improvement of the oil engine came about. During this time, however, the first practical gas engine was developed in France by J. J. E. Lenoir and patented in 1860. Although it did not embody any new features it was successful. To start the engine, the flywheel was pulled over, thus moving the piston which drew into the cylinder a mixture of gas and air through half its stroke. The gas was then exploded by an electric spark, which moved the piston to the end of its stroke, the pressure meanwhile falling, by cooling and expansion to that of the atmosphere when exhaust took place. In the return stroke the process was repeated, thus resembling a double acting steam engine, and having a one-stroke cycle. The engine was water cooled. The electric spark was supplied by two Bunsen

batteries and an induction coil, the circuit being completed at the correct intervals by contact pieces on an insulating disk on the crankshaft.

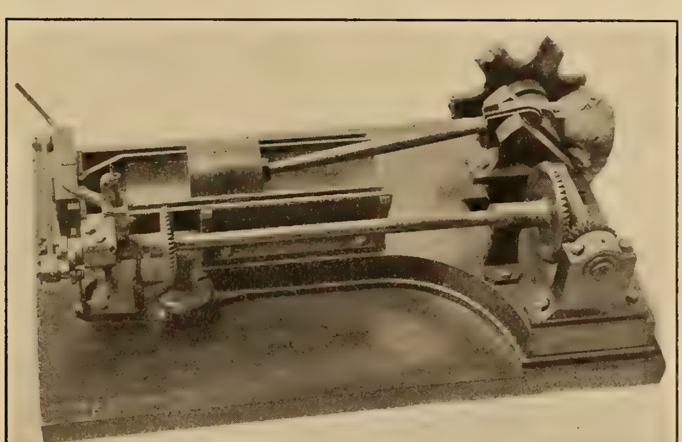
To get back to the oil engine. On June 17, 1873, a United States patent was issued jointly to L. C. Errani and R. Anders for new improvements in dynamic machines which the inventors called "a motor without gas." A photographic copy of the model submitted with the request for a patent is reproduced here. The invention is of interest in that petroleum (presumably the lighter oils) is stipulated and used for the propelling force. The motor is in general similar to an ordinary steam engine including a cylinder, reciprocating piston, crank and flywheel and valve-gear for operating, through a cam, a main valve connected with the cylinder.



OIL ENGINE INVENTED BY J. HOCK, AUSTRIA, 1874

The first practical successful oil engine of the non-compression type

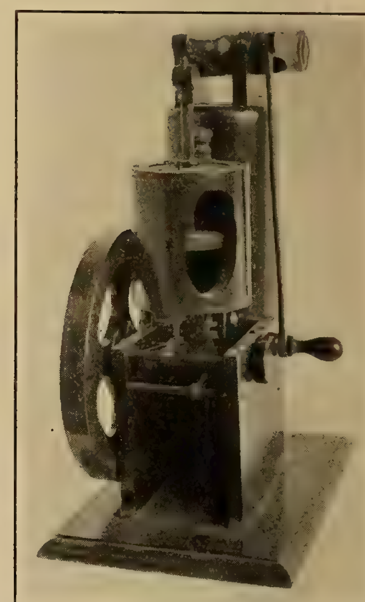
Instead of being actuated by steam, however, it is actuated by the expansive force resulting from the ignition, at the beginning of the "outstroke," of a mixture of petroleum and air sprayed into the cylinder through an aperture in its head. The oil spraying device operates on the same principle as that of the household atomizer and cologne spray. Beneath the engine is an oil tank, from the bottom of which protrudes a vertical tube. This is surrounded by an air chamber whose upper end terminates in a nozzle opposite the aperture in the cylinder head. Blasts of air obtained from a rubber bulb intermittently compressed by the action of a plunger operated by a crank on the main shaft, fill the air chamber, forcing the oil up the tube and out of the nozzle together with air into the engine cylinder. Upon the ignition of the oil by an electric spark, expansion moves the piston forward to the end of its stroke, and the impetus thus given to the flywheel returns the piston to its normal position ready for a repetition of operations. The quantity of oil sprayed into the cylinder is regulated by a cock in the charging pipe of the oil tank. When this cock is open, all of the air forced into the air chamber by the bulb compressor passes out of the oil tank through the cock and exerts no pressure on the oil which therefore cannot rise to the nozzle and the engine stops.



GAS ENGINE INVENTED BY N. A. OTTO, GERMANY, 1877

The first type of engine in which the explosive mixture was first compressed before firing. Also the first practical application of the four-cycle stroke. The invention revolutionized the internal combustion engine industry and founded the automotive industry

Less than a year after Errani and Anders received their patent, a patent was granted to J. Hock of Vienna, Austria, patent number 151129, May 19, 1874, for improvements on the Errani and Anders motor, which improvements resulted in the making of the first practically successful oil engine. A photographic copy of a model of this engine is reproduced here. Oil is supplied to the motor from an air-tight tank, the quantity being regulated by raising or lowering a plunger immersed in the oil. The cylinder end of this oil supply pipe is nozzle-shaped and is screwed into the cylinder head. Arranged in the cylinder head are one or more air nozzles directed across the path of the oil and supplied with air from a bulb similar to that of the Errani and Anders motor. The mixture of oil and air is ignited by a flame of gas directed horizontally into the cylinder through a hole in its head. The gas which is naphtha is obtained from a generator attached to the bulb compressor which generator consists of a tank containing petroleum. Air from the compressor is forced through the petroleum, yielding a mixture of naphtha and carbonized air. A portion of this gas passes directly to the engine cylinder, at intervals, and the balance is stored in a tank to supply a gas burner whose flame is in the path of the petroleum igniting gas and ignites it as it passes into the cylinder.



OIL ENGINE INVENTED BY G. B. BRAYTON, BOSTON, 1874

The earliest compression engine using oil as fuel

The engine cycle is as follows:

The gas burner is lighted and the flywheel turned. During the forward motion of the engine piston a small amount of petroleum is admitted and atomized by air. After the piston has moved a quarter stroke the air bulb is compressed, causing a blast of carbonized air and gas to be emitted from the generator. The mixture exits through a nozzle, is immediately ignited by the flame of the gas burner, proceeds into the cylinder and ignites the petroleum vapor within. The pressure created by the resulting combustion closes all valves and forces the piston forward to the end of its stroke and the impetus of the flywheel bring the piston back ready for the next charge.

The gas and oil engines developed up to this time were of the non-compression type. They were likewise heavy and awkward and gave little power. But, about the time that Hock obtained his patent, G. B. Brayton of Boston, Mass., obtained a patent, No. 151468, June 2, 1874, for an oil engine which worked on a constant pressure but without any explosion. This appears to be the earliest compression engine to use oil. A photographic copy of a model of this engine is shown here. The engine consists of a vertical cylinder,

single acting. On the crankshaft are two cams which operate the intake and exhaust valves located in the cylinder head. To the rear of the engine proper is an air tank with air under pressure as great as 60 pounds per square inch, maintained by the engine itself. A suitable valve regulates the amount of air passing out of the tank to the intake pipe. Surrounding the intake is an annular space stuffed with some absorbent material which is saturated at each revolution with a prescribed quantity of oil, the saturation being accomplished by a suction and force pump (to be seen on the engine bed) operated by a cam and connecting rod on the main shaft.

Above the intake pipe and the surrounding annular chamber is a circular opening in which is placed a wire gauze diaphragm, on the upper surface of which gas is constantly burning, the gas being supplied from an outside source.

To operate the engine the gas above the wire diaphragm is ignited, and the intake valve opened. Air from the tank enters the intake pipe and in passing upward permeates the absorbent material charged with oil through holes in the walls of the intake pipe. The oil now vaporized and mixed with air continues upward, passes through the wire gauze diaphragm and is ignited. The resultant expansion moves the piston upward and the impetus of the flywheel returns it. Should the temperature of the air be too low to vaporize the oil, its pressure is sufficient to drive the oil out of the absorbent in the form of a fine spray which upon striking the wire gauze diaphragm is instantly vaporized, mixes with air and is ignited as under normal conditions.

This brings us to the time when probably the greatest improvement in the internal combustion engine was made—namely, the compression of the explosive mixture in the engine cylinder before ignition and the introduction of a practical engine working on the four-cycle stroke. Both of these steps were made by N. A. Otto of Germany and patented in the United States August 14, 1877, patent No., 194047. The compression of the explosive was Otto's idea but the four-cycle stroke, it is now conceded, was proposed by A. Beau de Rochas of France in a treatise published in 1862, but it remained for Otto to develop it practically. By this system a much more diluted mixture could be fired than formerly, giving a more quiet explosion and a more sustained pressure during the working stroke, while, as the engine ran at a high speed, the flywheel action was generally sufficient to correct the fluctuations caused by there being but one explosion for four strokes of the piston. Although Otto developed and patented his ideas to apply to the gas engine, the advantages were soon recognized and almost immediately applied to the oil engine and are still so applied, further improvements being mainly in the direction of higher compression.

The illustration here shown is a copy of the sectional model submitted by Otto when he applied for patent rights. The engine is single acting, having a water jacketed cylinder. The piston having completed its "instroke" and about to be moved through its "outstroke" by the momentum of the flywheel, a slide valve opens to admit air. As the stroke proceeds, the air supply is cut off, and the combustible gas intimately mixed with air is drawn in until the piston has arrived at the end of its "outstroke." The gas port then closes and the piston is caused by the impetus of the flywheel to perform its "instroke," when the charge of gas and air that filled the cylinder is compressed and at about the time for the beginning of the second "outstroke," the gas is ignited, and the gradual expansion of the gases causes the piston to complete this stroke. The second "instroke" then expels the products of combustion through an exhaust valve. A fresh cycle commences on the next "outstroke."

The gas and air are admitted by a slide valve which serves also as an igniting valve, carrying a pocket of flame from an external light to a small port. The exhaust valve is of the drop type and is placed at the side of the cylinder. Both valves are actuated by a shaft driven by gearing at one-half the speed of the crankshaft. The speed of the engine is regulated by a centrifugal governor which when the normal speed is exceeded prevents the admission of gas.

Shortly after the introduction of the Otto gas engine, a motor of this type was brought out operated by an inflammable vapor produced by passing air on its way to the cylinder through the light oil known as gasoline. A further supply of gasoline was subsequently drawn into the cylinder to form the required explosive mixture which was then compressed and

AUTOMOBILE DESIGNED AND CONSTRUCTED BY CHARLES E. DURYEA BETWEEN 1892 AND 1893, THE SECOND MACHINE MADE BY HIM

The single cylinder gasoline engine also designed by Duryea is equipped with a "floatless" carburetor which by hand manipulation fixed the speed of the engine. There is no engine control from the driver's seat

GASOLINE ENGINE OF THE LANGLEY AERODROME, 1903

The lightest engine for its power built up to that time. Five stationary steel cylinders, water cooled. Horsepower, 52; weight, 115 pounds

fired. The Spiel petroleum engine followed and was the first Otto cycle motor which dispensed with an independent vaporizing apparatus. A light oil, of a specific gravity of not over 0.725, was injected directly into the cylinder on the suction stroke by means of a force pump. Upon entering it formed a spray, was mixed with air, vaporized, compressed and ignited as in the gas engine.

Up until 1883 the oil engines produced were heavy and cumbrous, rotating at a speed of between 150 and 250 revolutions per minute. Gottlieb Daimler, however, about this time conceived the idea of a small oil engine with light moving parts and to run at a speed of 800 to 1,000 revolutions per minute. In 1886 he made his first experiment with a motor bicycle and on March 4, 1887, ran, for the first time, a motor car propelled by a gasoline engine. While the motors developed by Daimler contained nothing new in their cycles of operation, great credit must be given him for realizing the possibility of producing durable and effective engines rotating at high speeds and for providing the first step in gasoline motive power development.

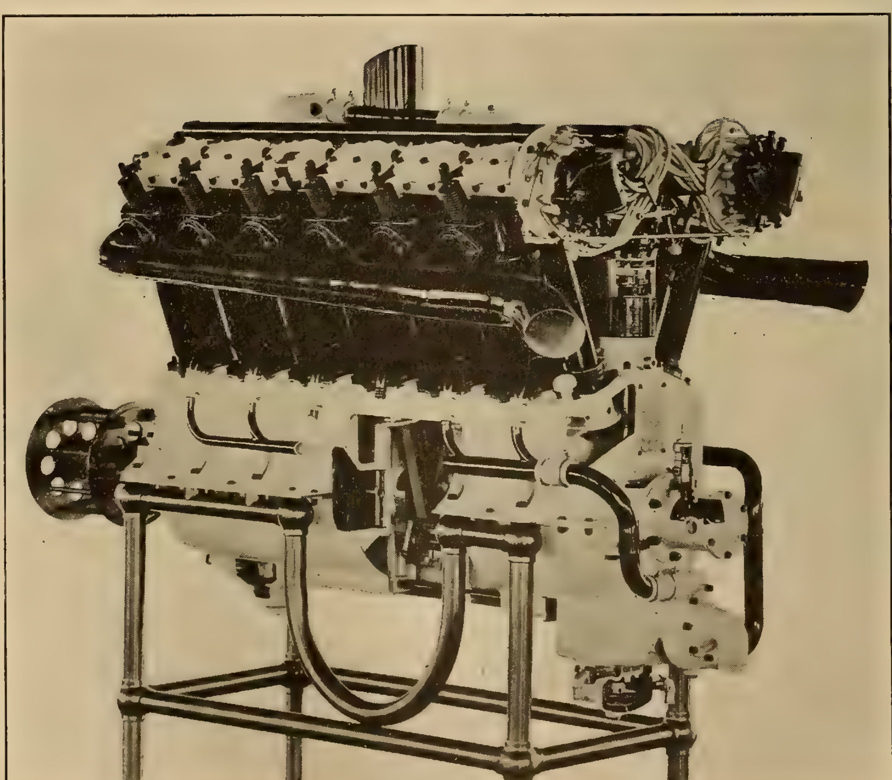
The date of the successful trial of Daimler's motor car marks the time of the divergence of the almost parallel paths of progress of the gas and oil engine; the gas engine continuing as an agent of power primarily for industrial use and the oil or gasoline engine branching off and advancing particularly as a motive power agent along which line it has made its greatest progress.

The possibilities of the gasoline engine brought to light by Daimler were almost immediately taken up and developed in Europe and the United States especially by Benz in Germany; by Panhard, Levassor, Peugeot, de Dion, Delahaye and Renault in France; by Napier, Lanchester, Royce and Austin in England; and by Duryea Brothers, Haynes, Apperson, Olds, Winton, and others in the United States.

The progress made since then in the development of the gasoline engine is far beyond the scope of this article, except in so far as examples may be given to visualize it. Thus, the Duryea Brothers when building their first "horseless carriage" in 1891-1892 had available for use the Daimler motors but, considering these far too heavy and cumbrous, they designed one of their own which was much lighter in weight and gave efficient service. A somewhat heavier one was designed for their second machine, reproduced here, which likewise was successful. This engine is equipped with a carbureting device on the order of a modern carburetor minus the float. Ignition of the "make and brake" type was used. Throttle control of the engine was thought impossible so that the engine ran at a constant speed (on the level).

When in 1900 Professor Langley of the Smithsonian Institution endeavored to procure a gasoline engine to propel his man-carrying aerodrome, such engine to develop a great amount of power but be light in weight, no builders could be found to undertake the work. An engine therefore was designed and built in the Smithsonian Institution shops under Professor Langley's direction, a photograph of which is reproduced here. The five cylinders are seamless steel shells, lined with cast-iron liners one-sixteenth of an inch thick shrunk into them. The combustion chambers entering the side of each cylinder near the top were machined out of solid steel forgings and secured to the cylinders by brazing. The cylinders are stationary and the piston rods are connected to the crank which operates a central main shaft. At a speed of 550 revolutions per minute the engine developed 52 horsepower. The entire power plant including cooling water, carburetors, batteries, etc., weighs less than 5 pounds to the horsepower. While this engine proved to be one of the lightest for its power ever made, its record did not hold for any considerable length of time for progress in design of gasoline engines did not stop there, but was ever moving forward. As evidence of this and as an indication of present day achievements contrast the Langley engine with the 1920 Liberty engine, the product of the best minds and skill in the whole American automotive industry—a twelve all-steel cylinder engine, having a 5-inch bore and 7-inch stroke, giving a total piston displacement of 1,650 cubic inches which develops 420 horsepower at 1,700 revolutions per minute and whose total weight is but 885 pounds.

The ancestry of the Liberty motor is thus established. Her direct genealogical tree, however, while not very old, say 225 years, is not of the conventional shape but more that of a tree whose growth for 190 years has been upward as a trunk but from which in the last 30 years have sprung many branches which recently have been joined together by their tips to form a pinnacle—the Liberty Motor.



LIBERTY-12, 1920
All steel cylinders; 5-inch bore, 7-inch stroke. Horsepower, 420 at 1,700 R.P.M. Weight, 885 pounds

ROAD SHOCKS AND RUBBER TIRES

WRITING in *Auto-Technik* (Nov. 6, 1920), A. G. von Loewe criticizes the efforts made to discover a solution of the problem of absorption of road shocks by substitues for rubber, and proves by means of calculations and analysis of stresses, that all designs, which rely upon springing without resiliency, must fail.

He endeavors to calculate the enormous stresses which a pneumatic tire must endure, and classifies them according to their direction as radial, tangential and transverse. When an obstacle is encountered by a car traveling at, say, 40 miles per hour, it produced a hanmer blow, part of which is transmitted to the springs, but most of the force must be absorbed by the resiliency of the tire else the vehicle will be smashed.

The stress set up by application of the brakes can be determined.

Producing Heat by Catalysis*

Flameless Stove Used by the French Army During the War

By R. Villers

IN 1817 Humphrey Davy succeeded for the first time in making a lamp without a flame. A spiral-shaped piece of platinum previously heated and then placed in a mixture of air and combustible gas, hydrogen or carbon-monoxide remains incandescent while the mixture is kept up, producing water vapor and carbon dioxide without alteration of the platinum. This reaction, which was purely experimental at that period, is today an inexhaustible source of new processes. The phenomenon of catalysis, in short, had been discovered! While catalytic action is applied in industry in the most multifarious manner, it has remained one of those phenomena as yet unexplained and to elucidate which many hypotheses are suggested. For the purposes of the present brief article we shall content ourselves with the following definition: The phenomenon of catalysis consists in the splitting up or the combination of one or more substances under the influence of some specific substance which itself takes no part in the reaction.

Silver in a pulverulent form, for example, decomposes hydrogen peroxide without itself undergoing alteration; aniline is produced by the mixture of hydrogen and nitrobenzine in the presence of platinum black; another application of catalytic action is the manufacture of sulphuric acid by what is known as the contact process.

These phenomena have been particularly studied by the French scientist, P. Sabatier, Dean of the University of Toulouse, and winner of the Nobel prize. But one of the most ingenious applications of this principle which has ever been made is the utilization not of the chemical phenomenon, properly so called, but of the heat emitted by the chemical reaction.

The apparatus invented for this purpose owes its origin, like so many other devices, to the war. As early as the winter of 1914-1915 our aviation service met with many annoying mishaps and disappointments because of the fact that when the order was given to make a reconnoitering flight the radiators had either been emptied to keep them from freezing or else their water was too cold to allow the motor to start; in either case time was lost with all that that implies in a state of war. It was necessary, therefore, to avoid such annoyances by finding some way to keep the water and the oil at a temperature sufficiently high to allow the machine to start at the first revolution of the propeller. This has to be done, moreover, without the use of a flame, in order to avoid the risk of setting fire to the highly inflammable plane, and without the use of substances which might be injurious to the crew or staff.

This very delicate problem was solved by Messrs. Louis Lumière and J. Herck by the creation of various catalytic heating apparatus whose use since the war has become quite general for heating purposes in situations where there is danger of fire or of explosion.

These apparatus, which have been patented by the inventors, make use of gasoline, which is decomposed by means of catalysis into water vapor and carbon dioxide through platinum in the presence of air.

In the diagram shown in Fig. 1, A represents an asbestos mat impregnated with platinum and serving as a top to B which has the form of the frustrum of an inverted cone. The member B rests upon another cone frustrum C, which forms the top of a reservoir D.

This reservoir is filled with a spongy substance, a sort of fleecy cotton, which absorbs the gasoline poured in and thus avoids there being an excess of liquid. A wick E extends into this reservoir; evaporation takes place from this wick in the chamber formed by the upper cone and mat.

The reaction continues automatically after having been started by a previous heating of the asbestos mat, which thereafter furnishes a heating surface having a temperature of 250° C. (482° F.); the action continues so long as the reservoir B has any gasoline left in it.

As for the previous heating of the asbestos mat this is easily accomplished by pouring a few drops of gasoline or alcohol upon it and setting fire to them; or by an electric resistance; or by means of a carburated gas obtained by using a bicycle pump, for example, to blow air through the opening employed to fill the tank, then lighting this gas above the mat.

It is evident that there is absolutely no danger connected with the use of this device, since during its operation it not only has no flame and no incandescent portion but it gives off absolutely no odor and no injurious by-product.

The work done is the maximum possible since the gasoline is entirely decomposed, developing the entire amount (about 11,000 calories), of heat representing its theoretic calorific power.

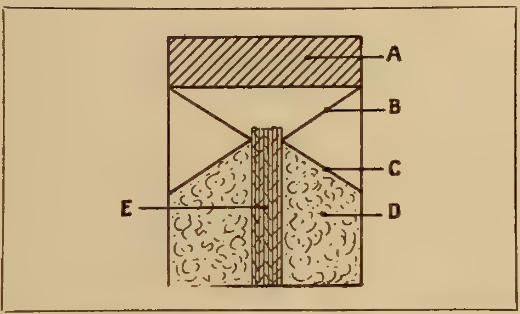


FIG. 1. DIAGRAMMATIC VIEW OF THE CATALYTIC HEATER

A number of highly practical pieces of apparatus operating on this principle are on the market under the general trade name *Thermix*.

One type which was used by the army during the war is meant to be placed, in cold weather, within the hoods of automobiles, etc., to avoid the necessity of emptying the water from the radiator, and to keep the lubricating oil in a fluid condition so as to facilitate starting the engine. Other types are meant for the heating of rooms as an auxiliary to the usual apparatus, stoves, radiators, etc., and not to take their place. These thermix stoves, for instance, can be used in the spring or the fall to warm up a chilly room, when only a few degrees of heat are necessary to make it comfortable. One of these consumes 60 grams of fuel per hour with a heating capacity of 30 cubic meters; the other uses 120 grams per hour with a heating capacity of 60 cubic meters.

Small pocket stoves and muff stoves are made upon the same principle and will run for eight hours with a fuel consumption of 1 gram per hour; these may also be employed to exhale perfume if a few drops of the latter be previously scattered upon the wick.

It is a simple matter to extinguish the apparatus. All that is necessary for this purpose is to cut off the air supply from the catalytic mat by means of the cover provided therefor.

It is quite evident that these thermix apparatus are very practical and that they can be made use of for many purposes other than those mentioned above; while as they become better known these heating apparatus at once economical, portable, and non-dangerous, will doubtless be more widely employed.

*Translated for the *Scientific American Monthly* from *La Nature* (Paris), December 25, 1920.

Gasoline by the Charcoal Absorption Process*

Description of the Activated Charcoal Process of Absorbing Vapors from Natural Gas

By G. A. Burrell, G. G. Oberfell and C. L. Voress

TWO methods of extracting gasoline from natural gas—compression and oil absorption—are now used extensively, while refrigeration is used to a limited extent. The charcoal process, a recent development operating on entirely new and scientific principles, compares most favorably with either of these methods. It produces higher yields and a better grade of gasoline. It does not require heavy initial installation costs and can be operated more cheaply. The apparatus has longer life and is not subjected to inefficiency due to wear. Its adaptability to field conditions is enhanced by the fact that it operates on either lean or rich gas at either high or low pressures.

This year there will be practically 300,000,000 gallons of gasoline produced from natural gas. Where the salable vapors in the gas are over a gallon per thousand cubic feet, it is possible to recover a considerable proportion by directly compressing and cooling the entire volume of gas. Where the salable vapors in the gas are not so plentiful, it has been the custom to resort to the oil absorption process, which is simply a method whereby the desirable vapors are concentrated by partial fractionation so that pressure and cooling may be effectively applied as in the original compression process. The gas is made to bubble or flow through absorbers where the gas comes in contact with a high-boiling mineral oil or naphtha which absorbs the heavier fractions in excess of the lighter ones. The oil or naphtha is then subjected to steam or direct heat to vaporize again the absorbed fractions so that they may later be condensed by cooling and compression.

DISADVANTAGES OF THE COMPRESSION AND ABSORPTION PROCESSES

There are several features of the present processes which are considered obnoxious by practical operators.

Both the oil absorption and compression systems require considerable pressure. The oil absorption may be used at low pressures, but it is not considered good practice because of the low saturations which must be adhered to. These high pressures are not only expensive to produce but mean large outlays for repairs and renewal of machinery. They also increase the danger of explosions.

Quite a little difficulty is experienced in marketing the product because of the large amount of so-called "wild" vapors which it contains. These vapors are the lower boiling fractions which have been absorbed and condensed in the higher boiling fractions by the compression, cooling and solvent action of the liquid. It has been apparent to many men for some time that a method whereby a sharp fractionation could be obtained would eliminate much of this trouble. Methods of hot blending and steam treatment have been used with varying success as a substitute for the original fractionation, but all admit that there is still much room for improvement.

The present oil plants are far from simple both in number of units and operation. Constant supervision is necessary if the oil plant is to be operated at as high a degree of efficiency as 75 per cent of gasoline extraction.

From the standpoint of pressures used, of quality of product, of efficiency of extraction, of simplicity of apparatus and operation, and of cost, a new process, one working on an entirely new principle, has been demanded.

CHARCOAL ABSORPTION PROCESS

The charcoal absorption process consists of bringing the natural gas into intimate contact with activated charcoal, in the capillaries of which the vapors are condensed and the dried gas allowed to return to the distribution lines. When a predetermined saturation of absorbed vapors has been attained in the charcoal, the gas is allowed to come into contact with a fresh supply of carbon. The vapors retained in the first mass of charcoal are then evacuated by distilling off with superheated steam, condensed in water-cooled condensers, blended and stored preparatory to marketing. Fig. 1 is a flow sheet diagram of the plant.

ACTIVATED CHARCOAL

The charcoal best suited for the successful operation of the process is made from cocoanut shells by the steam activation process developed during and since the war. Charcoals made by other methods do not possess sufficient absorptivity to pay for the costs of recovery and therefore are of no use in this process.

One very essential feature that the charcoal must possess is what we term selective absorption. Natural gas consists of the gases and vapors of the paraffin hydrocarbon series, the higher members of which have an appreciable vapor pressure at the temperature of the gas. When the gas is first brought into contact with the charcoal the lighter, high-volatile vapors, such as ethane, propane, butane, etc., are absorbed in the capillaries, but as the saturation increases a selection or equilibrium adjustment takes place with the result that these high vapor pressure and undesirable fractions are left in the gas. The heavier fractions are thus isolated and can then be condensed after steam distillation without the use of high pressures. Regulation of the vapor tension of the final product is thus obtained by preventing the absorption of the higher boiling fractions.

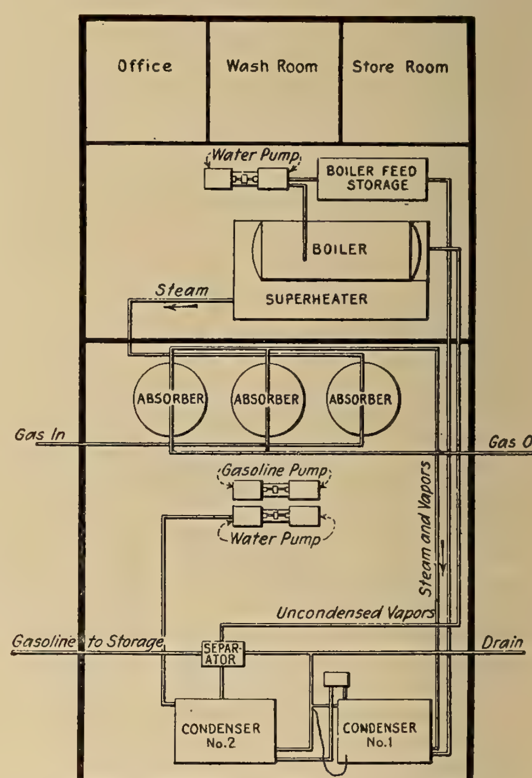


FIG. 1. FLOW SHEET DIAGRAM OF THE PLANT

The size of the granules of charcoal should be from 8 to 14

*Reprinted and somewhat abridged from *Chemical and Metallurgical Engineering,* Jan. 26, 1921, pp. 156-160.

mesh. Smaller mesh material has slightly greater absorbing qualities, but the resistance to the gas passage rapidly increases as the size of the granules decreases. Gas flowing through a column of charcoal 5 ft. in depth at the rate of 40 cu. ft. per hr. per sq. in. of base surface and flowing against atmospheric pressure will show a retardation of from 1 to 2 lb. due to the charcoal resistance.

ABSORPTION

When natural gas first comes into contact with charcoal considerable heat is developed, which is the latent heat of vaporization from the condensing vapors. After a few minutes the temperature stops rising, which indicates that selection is taking place and the heat of condensation is being used to re-volatilize the highest condensed liquids, which must be eliminated from the final product. Many investigators have ignored this phenomenon, and have stopped when no more heat evolution was noticeable, thinking that the absorption was complete. With gas rich in vapors we have observed a temperature increase of 60 deg. C. in the charcoal due to the latent heat in condensation. This does not mean that the entire body of charcoal increased 60 deg. simultaneously. The heated volume travels in a zone in the direction in which the gas flows. When using a tube of charcoal ¼ in. in diameter and 1 ft. in depth and passing rich gas at the rate of 10 ft. per hr., the heated zone is about 2 in. in depth.

The temperature of the charcoal at the beginning of the gas passage is not very important when using gas of low gasoline content. It quickly gains the temperature of the incoming gas. A loss of about 6 per cent in final recovery was experienced when tests were run with the initial temperature of the charcoal 300 deg. C. However, the temperature of the inflowing gas is more important. The curve of recoverable efficiency is practically a straight line function of the temperature, other things being constant. This curve reaches its zenith at 300 deg. C. Above that there is no recovery at all.

The rate at which absorption takes place varies according to the richness of the gas mixture. For gas yielding 400 gallons of gasoline per million cubic feet, a rate of 40 cu. ft. per sq. in. of base surface in a 5-ft. column of charcoal is not too high a rate. Above this rate the back pressure due to the resistance of the charcoal itself begins to enter as a factor against higher rates.

The volume of gas to be passed is determined by the nature of the product desired by the operator. If he desires a very volatile product, a low saturation of the charcoal must be had so as not to allow selection to eliminate too much butane, etc. If a staple low volatile product is desired, more gas is passed and the selection is carried as far as desired.

DISTILLATION

After absorption has been completed, it is necessary to expel the condensed vapors from the charcoal. This is done by blowing superheated steam directly through the charcoal. The superheat should be as high as local conditions will allow. There will be a decrease in fuel used per gallon of gasoline recovered, as the temperature of the superheated steam is increased up to the point where the radiation factor of the carrying lines and the efficiency factor of the heater itself become so large as to interfere. Local conditions affect this to a great extent. It will be found, however, that under ordinary conditions 250 deg. C. may be maintained with good results.

The amount of steam required depends upon the percentage of the available heat that is utilized. The charcoal must be heated to 200 deg. C. to dispel the heavier fractions of gasoline. This temperature also insures an active absorbent. The work done is mainly derived from the superheat. Calculations show that theoretically there are about 5,343 B.t.u. of heat required to produce a gallon of gasoline when the saturation is 13 per cent.

The question is repeatedly asked, "Does this steam distillation injure the charcoal for the other absorptions?" The steam distillation does not injure the absorptive capacity. In fact, it leaves it in a somewhat better condition than dry heating would. The steam drives out gases and absorbed vapors at a somewhat higher temperature than will permit condensation. The first rush of cooling gas will displace the steam and the first condensation will be of the vapors in the gas.

CONDENSATION

The gasoline vapors driven from the absorber with the steam may be condensed in any type of condenser. We prefer two water-cooled condensers in series. The cooling water around the first condenser can be circulated just swiftly enough to condense the major portion of steam and allow for its being trapped away without being cooled much under 100 deg. C. In many localities this condenser may well be an air condenser with enough of the line jacketed to heat the boiler feed water.

The second condenser must be an efficient one. With cooling water at 15 deg. C. or thereabout very efficient condensation will take place at atmospheric pressure.

The condensed gasoline and water flows from the condenser into a separating tank. If it is desired to blend the final product with heavier naphtha to reduce its vapor pressure, that may also be done at this point. We prefer to blend with from 10 to 15 per cent of about 56 deg. B. naphtha.

An examination of the gasoline produced has brought to light the fact that the gravity and vapor tension of this gasoline is less than the gravity and vapor tension of that made from the same gas by either compression or oil absorption. Fig. 2 is a set of curves illustrating this point. There are several reasons for this. Conditions under which the condensation is made affect the character of the final condensate. It has already been noted that the charcoal process gasoline is condensed from a vapor-gas system under atmospheric pressure. This is in direct contrast to the methods of condensation

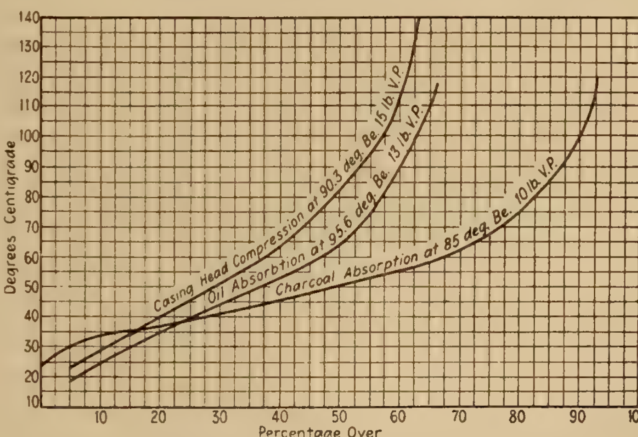


FIG. 2. COMPARISON OF GASOLINE PRODUCTS

used in the compression of oil absorption processes, where the pressure generally ranges between 90 and 250 lb. When these gasolines are placed in storage or released from compression, evaporation begins to take place immediately and desirable fractions of the gasoline are carried away mechanically with the escaping undesirable wild vapors.

The method by which the condensation is carried on is also an important factor in determining the character of the condensate. The charcoal process is a batch process. Consecutive distillations of a series of absorbers are made rather than continuous distillations of a single still. This drives out the lighter vapors first and makes possible the addition of the blending naphtha to the fraction that actually needs blending. If there are any very volatile vapors left in the charcoal, they are driven out first by the lowest temperature and do not come into contact with the salable gasoline. By the oil absorption method, which is a continuous process, all

fractions are driven out and carried to the compressors together. Here the salable vapors are condensed in the presence of the very volatile vapors under pressure, so that all the salable liquid must be saturated with wild vapors at the temperature and pressure used.

A third explanation for the better quality is found in the method of absorption itself. We have already mentioned selective absorption, which gives clear-cut fractionation controlled by the operator. The wild vapors are practically all re-evaporated into the gas within the absorber itself, thus preventing their presence in the steam distilled vapors and condensate later on.

Experience has shown that the product from charcoal absorption plants has 3 lb. less vapor tension and 10 deg. less gravity than gasoline made by an oil absorption plant operating the same gas.

Referring to Fig. 2, we see the results of applying the standard Bureau of Mines distillation test to the gasoline produced by the different methods. The initial boiling point of both compression and oil absorption gasoline is from 5 to 10 deg. below the initial boiling point of the charcoal gasoline. The final boiling points and the residue are practically the same. The curves of these distillations show that the big gain in yield is in the recovery of that product boiling between 30 and 70 deg. C., or within the range of the pentanes and hexanes. About 73 per cent of the charcoal absorption gasoline is within this class. Approximately 33 per cent of the compression and 38 per cent of the oil absorption are condensed between these temperatures.

The same series of tests showed that 93 per cent of the charcoal absorption gasoline is recondensed after the standard Bureau of Mines distillation and approximately 66 per cent

TABLE I. WEATHERING TESTS

I—First Pair. Air Temperature 65 Deg. F.

Time in hours	0	1	2	4	5	18	22
Oil absorption	1,000	995	970	950	940	856	850
Charcoal absorption	1,000	1,000	998	993	990	930	925

II—Second Pair. Air Temperature 65 Deg. F.

Time in hours	0	1	2	4	5	18	22
Oil absorption	1,000	994	968	950	938	854	847
Charcoal absorption	1,000	1,000	998	994	990	930	927

III—Third Pair. Air Temperature 80 Deg. F.

Time in hours	0	2	3	4	5	9	22	25
Oil absorption	1,000	965	945	935	922	890	830	828
Charcoal absorption	1,000	995	988	982	977	960	900	898

of the oil absorption and 63 per cent of the compression material were recovered. None of these samples had been blended before it was tested. The oil absorption sample had been made under a final pressure of 90 lb.

The weathering losses of gasoline made by the charcoal process are very light. Table I shows three pairs of weathering tests, comparing samples of gasoline taken directly from the blender of a charcoal plant and gasoline taken from the storage tanks of an oil absorption plant, where it has been allowed to weather under about 3 lb. pressure for more than two weeks. All samples were blended with 12½ per cent naphtha, 56 deg. B. Each pair was kept under the same atmospheric and temperature conditions.

After what has been said about quality, the reader may infer that the yield is being sacrificed. Such is not the case. A direct comparison between an oil plant and a charcoal plant operating on very lean gas showed that the oil plant averaged around 125 gal. per million cu. ft. of gas and had a weathering loss of 20 to 30 gal. before shipment. The charcoal plant produced an average of 203 gal. of high quality gasoline from this same gas on the same days. The reasons for this wide variation between the two plants are numerous. The problem of bringing every particle of gas into intimate contact with oil capable of absorbing the commercial vapors has always been difficult. Many kinds of baffles and sprays have been tried with varying degrees of success. With an absorber packed with from 8- to 14-mesh charcoal there is no difficulty in getting proper contact for complete extraction of gas.

The absorption of the vapors by a solid medium is governed by conditions entirely different from those governing the absorption by a liquid which depends on reduction of molecular area of the dissolved vapor. It is the capillaries of the charcoal which alter the vapor tension of the absorbed paraffine and make the absorption possible. The degree to which the capillaries are deepened and oxidized free from interfering compounds determines the absorptive capacity of any particular charcoal. However, difference in grades of carbon or any other substance which might be used for the framework of these capillaries is an important factor which must not be overlooked when studying the conditions governing the absorption of gasoline.

The absorption process is actually a modification of the compression process, which consists of concentrating the recoverable vapors before applying the compression. But by the compression method it is possible to condense only a certain part of each fraction included in the gas. This part is determined by the number of fractions present, by the percentage of the different fractions present and by the temperature and pressure employed. It is only a specific application of the partial pressure laws. The addition of air or any gas not condensible at the working pressures means loss in efficiency.

HAY CAKE—A NEW FODDER FOR CATTLE AND HORSES

FROM time immemorial it has been customary to prepare winter fodder for cattle and horses, by cutting and drying the grass of their pasture to form hay. Of recent years this ration has been supplemented, not only by dried grain, such as oats and corn, but by various sorts of "cake" such as cottonseed oil cake, etc.

A recent observer, Mr. Gain, has conceived the idea that it would be advantageous to prepare hay in a similar form instead of feeding it to the animals in dry wisps, as is usually done. in a report to the French Academy of Agriculture he described the processes through which the hay must pass in order to prepare it in the aforesaid form.

Physical Treatment.—The hay must first be chopped and sifted and then passed over an electro-magnet to remove particles of metal. In this condition it may be fed to horses, mixed with crushed oats.

The cake thus produced may be partially cooked at a temperature of 60° C.

Chemical and Biological Treatment.—In a good specimen of hay the ratio between the nitrogenous and the non-nitrogenous elements is at 1: 8. But there are certain kinds of hay which are poor in liguminous substances and which have been grown upon acid soil which have only from 1/10 to 1/13 of the nitrogenous element, and which are even poorer in fatty substances.

Mr. Gain experimented with the *Juncus silvatiuas*. He incorporated with the cake made of the chopped hay the dried blossoms contained in the litter laid down for the animals.

The application of a fermentation process is chiefly of use for partially attacking the indigestible cellulose. For this purpose he made use of the floral bacteria contained in the contents of the paunches of slaughtered cattle. He also made use of steam in an autoclave for modifying the cellulose.

In brief, therefore, the preparation of the hay cake requires chopping, compressing and sometimes boiling in fermentation.

The question resolved itself largely into one of economy under given conditions, but the last mentioned process, the so-called biological treatment by means of fermentation is worthy of special attention, since but little mechanical energy is required for such a treatment, and the resulting by-products are small in amount as compared with the bulk of the fodder produced.

STRIPPING THE BARK OFF THE ABACA TREE AND CARRYING IT TO THE FACTORY

PRIMITIVE METHOD OF SHREDDING THE LEAF STALKS AND SCRAPING OFF THE PULPY MATTER

Manila Hemp

Primitive Methods of Obtaining Hemp from the Wild Banana Plant

By S. G. Williams

Photographs Copyright by Keystone View Co.

"IN union there is strength" is, perhaps, no more beautifully typified than in those combinations of fibers ranging all the way from twine to the greatest of sturdy towing hawsers. By the skilful assembling and disposition of really delicate filaments, our manufacturers of ropes produce a variety of commodities capable of meeting service stresses measuring many hundreds of tons. How little most of us know about this industrial art that plays so prime a part in endless directions in the daily life of America's multitudinous activities.

Thousands of years ago, primitive man realized that he needed pliant lengths of materials with which he might pull and bind; and in the days when hieroglyphics served to record the high spots of ancient civilization the scribe pictured for the ages to come how it was possible to fashion the fibers available into ropes strong enough to handle the massive rocky units with which the pyramids were built. The peoples of succeeding eras have, in the main, elaborated upon the principles then employed and have gradually evolved mechanical agencies designed to work faster and upon a scale quite out of the question where manual dexterity was the sole reliance. No country has achieved more in this direction than the United States; and infinite skill, inventiveness, and engineering cunning have put us at the forefront in this department of endeavor.

In the days of the sailing ship, rope figured more conspicuously aboard every floating craft; and anyone at all familiar with maritime matters was alive to the multiple ends served by hempen cordage of all kinds. Fiber rope then was inseparably and peculiarly associated with the needs of the seafaring fraternity. In the popular mind, that was the period when rope was in its preëminence; and there is a widespread and mistaken belief that with the shift from belching canvas to steam for propulsion the demand for cordage dwindled. It is a matter of fact that our consumption today is vastly more extensive than it ever was before, all because of the diversified uses which have developed latterly for cord, twine, and rope of well-nigh endless sorts. The manufacturer's problem now is not so much one of mechanical facilities as it is that of an abundance of the raw stuffs which are able to meet the standards imposed. Life, property, and the successful execution of hundreds of thousands of tasks depend upon the way in which cordage stands up to its work when the load is applied. It has been said that the world at large needs fully twice as much fiber as is at present brought to the far-flung markets, and for that reason experts are searching everywhere for new fibers susceptible of adaptation.

In the rope-making industry there are now commonly employed but three vegetable fibers, and these, named in the order of their importance and service value, are Manila hemp, sisal, and jute. A further classification places hemp and sisal in one group, *i.e.*, that of the hard fibers, while jute is designated as a soft fiber. However, there are soft hemps, such as those grown in sections of this country and abroad in Russia and Italy. These fibers are not deemed of sufficient strength to warrant making them up into any but

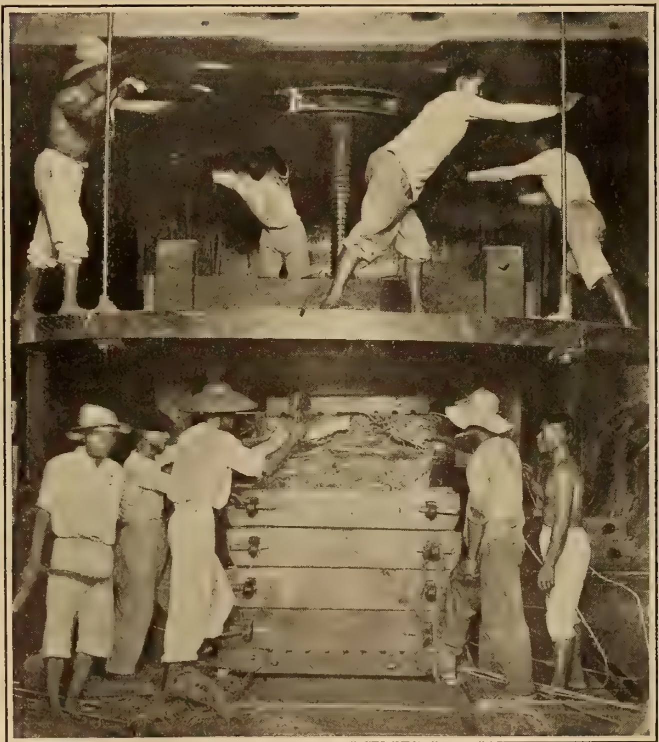
A NATIVE MACHINE FOR STRIPPING THE LEAF STALKS

NATIVES BRINGING BALES OF HEMP TO MARKET

the smaller runs of cordage. The prime hard hemp comes to us well-nigh exclusively from the Philippines where there are under cultivation quite 1,236,000 acres of this particular species of the wild banana plant, botanically known as the *abaca*. While the fibers of this hemp are weak when stressed laterally still the filaments are very strong longitudinally. Repeated tests reveal that the best Manila fiber has a tensile strength of 30,000 pounds per square inch of section. And to add to the fitness of the material for the manufacture of the finest and heaviest cordage, the filaments have an average length of from 6 to 10 feet. This permits the fibers to be intimately twisted and united with a minimum of separate elements in a given measure of rope.

The abaca grows in dense masses to a height of from 15 to 25 feet, thanks to a soil of volcanic origin and the abundant rainfall of our far-eastern possessions, and reaches the cutting stage in something like 14 months. The plants reach the most favorable condition for yielding fiber just before they reach the flowering stage. The plant is then cut down and the leaf stalks that sheath the central peduncle are stripped off. It is from these leaf stalks that the fibers are obtained.

In Europe and America, the native-grown hemps are subjected to a retting process, akin to that resorted to in the case of flax, by which the pulpy substance is got rid of by mild putrefaction without harming the hair-like fibers. But in the Philippines, the manual skill of the natives is relied upon to effect the separation, and the cheapness of labor makes this commercially practicable.



BALING THE HEMP WITH A FOUR-MAN BALING PRESS

The strips of leaf stalks are laid aside in the shade to dry for two or three days after which without any further preparation they are ready to be scraped. The scraping process removes the pulpy matter and leaves only the fiber.

As shown in our photographs the natives use a rude home-made stripping apparatus built out of materials at hand. This apparatus consists essentially of a block of wood and a knife between which the leaf stalks are drawn. The handle of the knife is fulcrumed close to the block and its outer end is tied to a bamboo pole which serves as a spring to hold the knife down on the block with a considerable, though resilient, pressure. By means of a foot pedal, also connected with the knife handle, the operator can raise the knife against the tension of the bamboo pole so as to permit of introducing the leaf stalk under the knife. Some of these native stripping machines are very ingeniously contrived.

The operator uses a small piece of bamboo as a hand hold around which the end of the leaf stalk is twisted and then draws the leaf stalks between knife and block. Repeated scraping removes the cellular matter around the fibers so effectually that no further treatment is necessary other than to hang up the hemp to dry.

About 25 pounds of fiber, cut and scraped, represents a day's work of two men and it takes about three thousand plants to produce a ton of fiber. Al-

CLEANING THE HEMP BY DRAWING IT OVER POINTED SPIKES WHICH PULL OUT DIRT AND SHORT FIBERS

WINDING UP THE FIBER ON SPOOLS FOR USE IN MAKING FINE FABRICS FOR WHICH THE NATIVES ARE FAMED

though efforts have been made to introduce power driven machinery for stripping the fibers, they have not been successful particularly in view of the low cost of labor in the Philippines, and the native with his crude stripping apparatus has not yet materially felt the competition of modern mechanical progress.

The hanks are made ready for export by packing in bales weighing generally 270 pounds. Before baling, however, the material is graded by experts of long experience; and there are thirty-odd grades of the fiber used in the production of cordage. This indicates how necessary it is to choose with the utmost care the hemp designed for different kinds of rope. The relative value of the hemp is contingent upon the way the stripping and cleaning are done; and the primary strength of the fiber is the result of the age of the plant.

The native method of cleaning the hemp is to drag it across a set of spikes which comb out the dirt and short fibers. The natives twist the fiber into rope yarn and make the yarn into rope. The finest fibers are used in native looms to make delicate textiles. The fibers are not spun or twisted but are gummed or knotted at the ends. Fine gauzes and veils are made of this material, also light crapes and fabrics which are much prized as articles of dress because of their lightness and durability.

Not only is the hemp graded before it is bought and shipped from the Philippines, but it is inspected thoroughly after it reaches the rope manufacturer in this country. Here, the hanks are assorted according to their length, texture, tensile strength, and color by men long familiar with handling the raw commodity and equally at home with every stage of its preparation into cordage. Hemp of a marked whiteness and silky luster is at a premium, and is fashioned into the very finest of high-priced rope to meet a market demanding both superior appearance and endurance.

PRIMITIVE ROPE-MAKING IN THE PHILIPPINES

POISON FOR RODENTS

A fair variety of chemicals enters into the campaign against rodents which has sprung up in different parts of the world. In Australia tens of thousands of rodents have been killed with phosphorus. In Japan and the Philippines white arsenic has been used exclusively against rats, and lead arsenate has been used with good results elsewhere. It has been found that where strychnine can be safely used it is to be preferred to other poisons for field use. About buildings barium carbonate has given excellent results and is to be recommended, because it is comparatively harmless to domestic animals. The *London Times* states that experiments at the Zoölogical Gardens in London have disclosed the fact that from 10 to 15 grains of barium carbonate was harmless to a chicken and find a hundred grains produced no ill effects in the case of a duck. Rats, however, are killed by as little as one and a half to two grains.

The poisons commonly used are arsenic, strychnine, phosphorus and barium. Corrosive sublimate and cyanide are not recommended as rodent poisons. Many recipes for rat poison contain more than one poison, but it is now recognized that a bait in which a single poison is used is generally superior to one in which two or more have been included. Where powders are to be employed a satisfactory formula is flour containing about 10 per cent of powdered strychnine to which saccharine can be added.

Seeing Submerged Objects

Augmenting the Visual Power of Field Glasses by the Use of Analyzers

THE possibility of improving the visual power of field glasses, etc., by the employment of so-called "analyzers of light" is interestingly discussed in the *Official Bulletin of the French Bureau of Research and Invention* (Paris) for Feb., 1920, by M. Henri Bénard, under the title "Utility of Polarized Light in Observations Made at Sea and on the Seashore by Means of Field Glasses Equipped with Polarizers." We are indebted for the following abstract of this paper to the *Revue Scientifique*, Sept. 25, 1920.

On Dec. 2, 1835, Arago presented to the Bureau of Longitude an instrument composed of a tube and a piece of tourmaline with the statement that the latter substance "eliminates the light reflected from the surface of the water and enables the observer, consequently, to perceive objects lying at the bottom of the water." He also described the operation of the device in the following words: "Let us suppose that the line of vision is inclined to the surface of the sea at an angle of 37°. The light which is reflected at this angle to the external surface of the water is completely polarized. As all physicists know, polarized light refuses to traverse suitably situated slices of tourmaline. Hence such a slice of tourmaline is capable of totally eliminating the rays reflected by the water which were mingled, in the direction of the line of vision, with the light proceeding from the object under water, either eliminating them entirely or at least greatly weakening them.

"When this effect is produced the eye placed behind the slice of crystal receives, therefore, only one sort of rays—those coming from the objects under water; instead of two superposed images upon the retina there is only a single image and this, of course, considerably enhances the visibility of the object observed.

"The absolute elimination of the light reflected from the surface of the sea is possible only with an angle of 37°, since it is with this angle alone that polarization is complete; however, with angles 10° or 12° greater or less than 37°, the number of polarized rays contained in the beam of light reflected, (the number of rays which can be stopped by the tourmaline) is still so considerable that its use as a means of observation ought to give excellent results."

In accordance with the laws just stated Arago suggested a series of experiments to be made at sea with respect to the visibility of the rocks and reefs. Something like a hundred years later M. Henri Benard has been conducting experiments similar to those suggested with respect to the visibility, not merely of rocky reefs, but also of all submerged objects and especially of submarines.

It is a matter of regret that M. Benard was either ignorant of this previous work done by Arago, or else did not see fit to mention it; nevertheless he undoubtedly deserves credit for calling attention anew to the possible utilization of well-known phenomena in practical apparatus.

He begins his remark by recalling that the two luminous depths, the sky and the sea, against which the objects which one observes upon the seashore or during an ocean voyage stand out, are both more or less completely polarized, especially in fine weather (much less so in cloudy weather) while the reflection from the surface of the sea is also polarized when it is present. But if we now provide the instrument used to make our observations with an analyzer whose plane of polarization can be revolved at will, the observer will find himself able to regulate at pleasure between two definite limits the intensity of the luminous depth, against which the remote objects to be observed are delineated—in other words, he finds himself able to create or modify for the better photometric contrasts.

Of all the white objects which may be observed by analyzed light that which exhibits the most exaggerated contrast is the foam on the surface of the water whether due to the breaking surf or the passage of a boat.

The objects named below are also considerably improved in visibility especially when the sun is in the same direction from them as the observer; light colored sails of boats; seashells or muddy deposits of light color; persons in boats (provided their faces, hands, and garments are light in color); and white plumes of smoke from the funnels of steamships; and along the shore, houses, walls, forts, dykes, rocks, etc.

Improved Color Perception.—This so-called analyzed light likewise considerably enhances the perceptibility of colors in the objects sighted at sea. In this case the gain in the degree of perceptibility is really surprising—whereas ordinarily it is a well-known fact that it is difficult to discern the true shades of objects seen at sea, we find by the use of these analyzers that vari-colored muds exhibit their natural vivid coloring, and all the various colors in the bands upon smoke stacks, the clothing of men and women, etc., etc., instantly appear in the field of the spyglass as soon as the analyzer is so placed as to extinguish the reflection from the sea.

It must be admitted that there are also cases in which the visibility is diminished. Dark objects, for example, such as rocks, earth, and black-painted boats, stand out very clearly against the light, silvery gray background and gain nothing, on the contrary, when the analyzer is revolved, so that the background becomes black or dark bottle green. But even in this case it is advisable to examine the object after it has been located with the extinguishing analyzer, even if only to study the details under different shade of color. It is necessary, obviously, that the analyzer be capable of being revolved successively into the two positions.

The two methods of observation complement each other, giving the observer the exact amount of information, since it is evidently quite possible that there may be within the field of the glass both light-colored objects which are practically invisible upon a sea of shining silver, and dark or black objects which canont be discerned upon a dark green background.

Devices Employed in Practice.—In conclusion we may state the best conditions in practice for adapting various analyzers to prismatic field glasses.

Reflection polarizers consisting of two black glass sides placed parallel in order to bring the direction of the line of vision back to its initial direction should be eliminated, since they allow only a very small amount of incidental light to pass through, and the same thing is true of a single black glass as well as of a total reflection prism.

Absorption polarizers such as tourmaline, which extinguish one of the two rays due to the double refraction consist of colored crystals, which, when employed in suitable thickness absorb a large part of the vibrations which traverse them. But for many uses the green or pink color of tourmaline would be very annoying, since it would involve the relinquishment of one of the principal benefits to be gained, namely, the exact determination of colors. On the other hand the use of a very thin slice of tourmaline, which can be readily shifted, reduces to a minimum the required modification of field glasses and spectacles already in the observer's possession. The use of such a thin slice would be indicated, if one desired merely to diminish or suppress the sparkling brilliance of the reflection of the sun upon the water.

Analogous properties to those of tourmaline are possessed by an interesting artificial, dichroic crystal—*iodo-sulphate of quinine* or *herapathite* if it be employed in extremely thin layers. By transmitted light a layer of herapathite is a light violet gray in color, a shade which modifies but slightly the objects observed. Unfortunately, the preparation of lamillæ of herapathite is a very delicate matter.

By refracted prisms of Iceland spar, rendered achromatic by means of a crown prism or a simple slice of the spar having parallel faces, are not capable of sufficiently separating the ordinary and extraordinary rays. We are reduced, therefore, to the employment of assemblages of prisms of Iceland spar, such as the Nicol (a slice of Canadian balsam) or the Foucault (a stratum of air) so arranged as to eliminate one of the two rays by total reflection. The analyzer may be so placed between the eye-piece and the eye of the observer as to modify but slightly the construction and optical properties of a prismatic field glass. M. Benard gives a description of the manner in which he modified, so as to permit vision by analyzed light, the ordinary field glass constructed by Jules Huet et Cie.

The only obstacle to the general user of such devices—but a pretty serious one—is the scarcity of Iceland spar whose known deposits throughout the world are so limited in extent that they ought to be reserved as far as possible for purely scientific purposes. A technical and scientific problem, whose solution would be of great importance, would be the discovery of an analyzer as efficacious as a Nicol prism, but less costly.

Taking Photographs in Relief*

Louis Lumière's New Process of Photo-Stereo-Synthesis

At the meeting of the French Academy of Sciences held November 8th, M. Louis Lumière made an important communication to the assembled savants concerning a new method by which he has been able to take photographs of "solids in space," i.e., photographs which indicate three dimensions instead of two in the manner of a relief map or of image in a stereoscope. We give below the essential elements of the method employed with diagrams of the apparatus.—EDITOR.

WHEN upon a fixed scale photographic negatives are taken of a series of parallel planes (whether they be equidistant or not) of an object, each image representing, of course, only the intersection of the object by the corresponding plane, it is possible to reconstitute, in space by superposing the positives of the said negatives, the actual appearance of the object photographed. To achieve this it is only necessary that the distances of the positive images shall be equal to that of the photographic planes affected by a coefficient corresponding to the scale adopted.

To obtain such a reconstitution which would be theoretically perfect we should have to superpose an infinite number of images infinitely near to each other. This condition obviously cannot be realized in practice, but M. Lumière has shown by experiments that it is not necessary to do this in order to give the eye impression of continuity, and that comparatively few elements will suffice provided that within a certain limit each image shall correspond, not to a plane (which is furthermore an impossible condition) but to a given focal volume. This focal volume must, of course, be small enough to avoid the effects of parallax beyond vision.

If the experimenter attempts to secure this by means of the greatest comparative aperture at present attainable, he will find that the depth of the field is still too great by far. To obtain the required reduction of focal volume M. Lumière has devised two methods based upon the following principles:

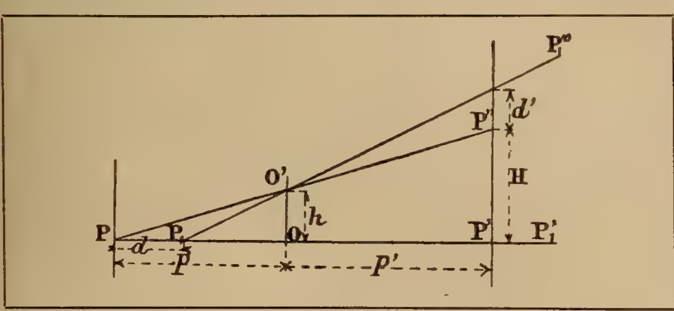


FIG. 1

1. Let O (Fig. 1) represent a lens with a plane field giving an image P′ of the point P situated upon the principal axis. If the lens be moved through a distance h so that its axis remains parallel to itself and that its principal planes are held motionless in space, the image P′ will fall at P″ situated in the conjugated image plane of the object plane containing the point P.

If, at the same time, the operator causes the image plane to move, in the same direction and without rotation upon itself through a distance H so that we obtain the equation $\frac{h}{H} = \frac{p}{p + p'}$ then the position of the image of the point P will not have changed with respect to the limits of this plane. The same thing will be true of all other points situated in the conjugated plane of the image plane.

Thus we shall have no points such as P_1 situated on this side or on that side of the object plane. To each distance d of this plane there will correspond a displacement d' of the corresponding tracing of the secondary axis upon the image plane and the value of d' will be given by the equation

$$d' = \frac{hp'}{p - d} - (H - h)$$

The image of the point P_1 will, therefore, leave upon the sensitive surface a tracing of the length d'.

2. In the second method (Fig. 2) let O be a lens provided with an inverting prism and giving the image P′ of the point

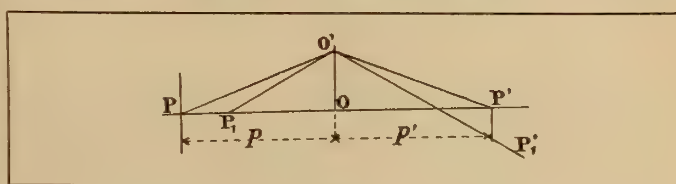


FIG. 2

P, p and p′ being necessarily equal taking into account the elongation resulting from the interposition of the prism.

If this lens be made to undergo a displacement of any amplitude whatever in the plane of the principal section of the prism and this plane, as well as the principal planes of the lens, remains invariable in space, then the position P′ of the image of the point P will not have changed. On the other hand the image of every point situated on one side or on the other of the object plane will undergo displacement in accordance with the equation given above. It will suffice, therefore, in order to reduce the focal volume to provide the lens with two inverting prisms whose principal sections shall be placed at 90 degrees from each other and to displace the axis of the lens parallel to itself, taking care to keep the principal sections likewise parallel to themselves during the displacement.

As a result of this arrangement it becomes possible to take a photograph of a surface of any extent whatever by means of a lens having any focus whatever.

For example, one which is very small with respect to the dimension of the surface photograph.

In order to apply these principles M. Lumière first constructed an apparatus satisfying the conditions set forth in the description of the second method, but since this did not give perfect results because of the lack of prisms cut in the proper manner, he then constructed the apparatus shown in Fig. 3, which satisfies the conditions set forth in the first method. Two vertical frames connected by cross-pieces (not shown in the drawing) provide bearings for four shafts A, B, C and D. There is a crank arm on each end of the

*Translated for the *Scientific American Monthly* from an abstract published in *Le Genie Civil* (Paris) for Dec. 4, 1920.

shafts and each arm carries a stud. The ratio of the length of the worward arms to the rear arms is equal to $\frac{p}{p + p'}$.

The forward studs enter sockets in the front board of the camera and the rear studs similarly support the back of the camera. The front board and the back are connected by the usual bellows. One of the shafts carries a pulley by which it is possible to rotate the entire system during the time of exposure.

It is evident from the principles above elucidated that every point situated outside the conjugated object plane of the image plane corresponding to the given ratio $\frac{p}{p}$ will produce upon the sensitive plate a circular tracing, the magnitude of whose diameter will be in direct proportion to the distance of the given point from the object plane. Furthermore the circle of diffusion corresponding to the orifice of the lens is also a factor in the disturbing of the *definition* at this point. Only those points which are situated in the conjugated image plane

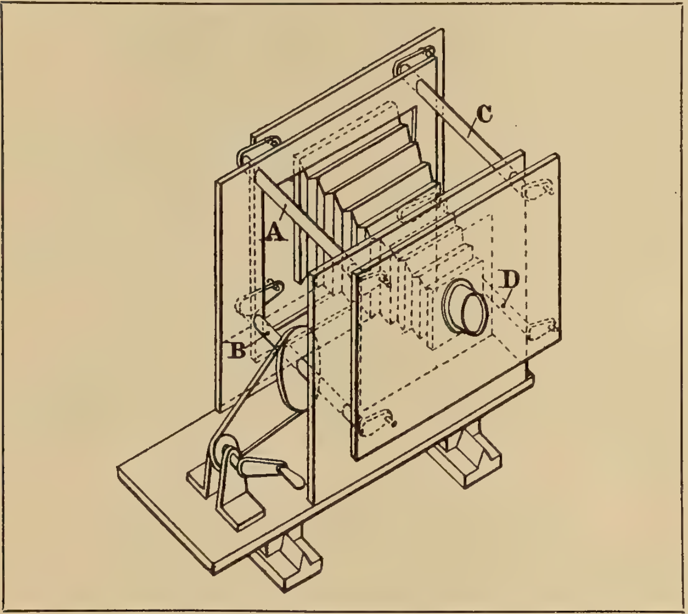


FIG. 3. DETAILS OF LUMIÈRE'S NEW CAMERA

of the object plane will be clearly defined. The angular orifices of the lenses at our disposal will suffice to enable us, provided a high value be given to h, to localize the extent of the clearness of definition in depth to a very reduced volume, but experiment demonstrates that in practice it is difficult, if not impossible to exceed, for the circumference described by the lens, a diameter of more than 80 millimeters. Under these conditions the apparatus will enable us to obtain, if a lens of comparatively large aperture be employed, highly interesting results, as was demonstrated by the examples exhibited to the Academy by M. Lumière.

PHOTOGRAPHIC RESEARCHES

The researches made by the French scientist, H. Buisson and others concerning photographic plates as employed during the war have recently been made public. We refer especially to the data which have a general scientific character.

The first series of researches was made as follows: A continuous spectrum is projected upon the plate, with a constant exposure for each case, this being produced by a prism spectroscope with dark chamber or camera portion whose plate holder can be displaced so as to obtain several exposures on the same plate. The slit has a constant width and receives light from a 100-candlepower ½ watt incandescent lamp. After developing the plate during a standard length of time in a constant bath and at uniform temperature, the plate is washed and fixed. The amount of blackening of the various parts of the spectrum is then measured by the microphotometer devised by C. Fabry and H. Buisson, and the value is then plotted so as to form a curve whose ordinates represent the density and the abscissæ the wave-lengths. It should be mentioned that in order to effect the evaluation of the blackening of the plate, this latter is traversed by a beam of light, and the ratio between the intensity of the beam before it passes through the plate and after traversing the same (it being of course more or less diminished thereby), is termed the opacity or the blackening effect. The logarithm of the opacity is termed the density, and this latter is proportional to the amount of reduced silver per square centimeter of the plate. It is to be noted that the present curves for the blackening effect have only a relative value and hold good only for comparisons made with a given apparatus, since the spectrum is obtained by a prism which has the effect of condensing it toward the red, thus increasing the intensity in this region.

According to the results of these tests, the plates are classified in several groups, according to their sensitiveness to the spectrum. Setting aside the ordinary plates, whose sensitiveness is limited to the violet and blue, the first group will contain the plates showing their maximum effect in the yellow-green, comprising certain commercial German plates as well as some English plates. In this group some of the emulsions have only a slight sensitiveness for blue and violet, and can thus be employed without a yellow screen. The second group comprises plates of a maximum sensitiveness in the red, some of these being almost unaffected by the red-yellow, such as the English plates termed "red sensitive." A third group contains plates which have two or three very pronounced sensitive regions; blue, green and red, as well as plates having a practically uniform sensitiveness, or the panchromatic plates.

The second series of researches related to the general sensitiveness of the emulsions. In fact, it is not sufficient that a plate shall be acted upon by a given wave-length, but this action should represent the greatest possible amount for a given amount of light. For use in aerial photography especially, the best plate will be the one that gives an image with the shortest exposure. On the other hand, a plate should be chosen which has the best gradation according to the effect to be obtained, for instance in observation work it is of value to exaggerate the contrasts, since the purpose is not to obtain a harmonious image but to distinguish the smallest details and the least differences in intensity which will reveal the points which the enemy are trying to conceal. Researches upon sensitiveness and gradations are carried out by exposing the plates to lighting which has the same value but is applied in a series of varying exposures. The Scheiner sensitometer is found the most suitable for this work, its essential feature being a rotating disk having cut-out sectors whose width increases in geometrical proportion. M. Buisson used one of these instruments which had 9 sectors, each having double the angular length of the preceding, thus giving a series of exposures in the maximum ratio of 1 to 512. It is to be noted that these sectors are situated upon concentric circles, each sector or arc-shaped hole having a different length from the preceding, as stated, and the openings are not in the form of segments bounded by radii of the circle. The disk is rotated by an electric motor, and is located in a chamber placed back of the camera chamber. The light coming from a rather distant source will thus traverse the rotating disk and fall upon the plate. Color sireens can be interposed.

The plates are developed in an identical manner, then the densities are measured for all the regions acted upon by the light. The results are represented graphically by using as abscissæ the logarithms of the times of exposure given by the length of the sector openings, the ordinates being the densities of the corresponding regions. This gives a curve having a rather long straight part, representing what is sometimes called the region of normal exposure. The angular coefficient of this straight portion, termed "development factor," characterizes the degree of contrast which a given plate will afford. Where this factor is small the plate has but little contrast, and, if large, the plate has exaggerated contrast.

The X-Ray Detective

Some Curious Uses of the All-Seeing Roentgen-Ray

By Gordon Vanderveer

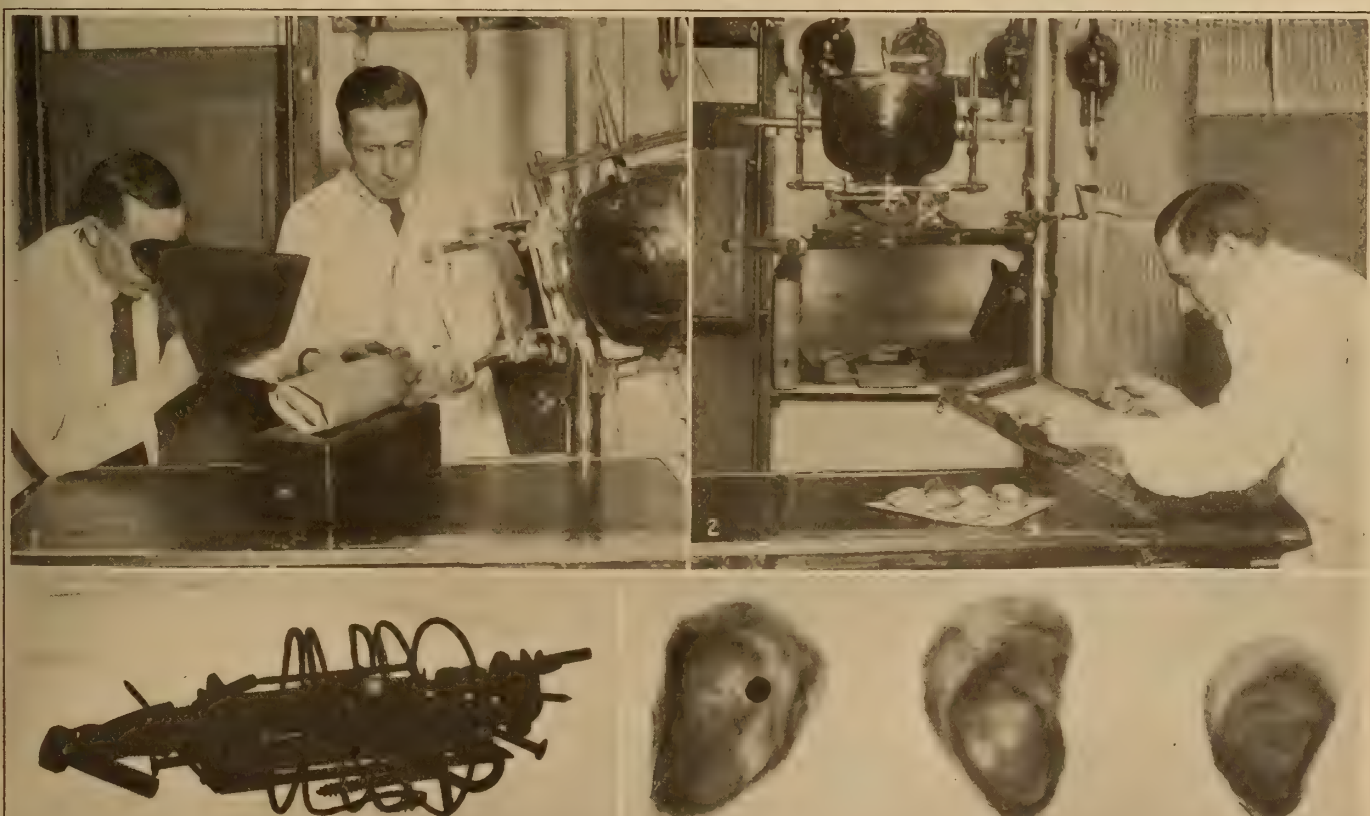
WE are all familiar with the use of the Roentgen rays in surgery to reveal the internal structure of a patient and locate the position of foreign bodies, or disclose the nature of a bone fracture so that the surgeon, before he undertakes an operation, is fully acquainted with the character of the trouble that he has to deal with. It is also generally known that the extent of certain diseases and their nature may be determined by means of these penetrating rays, and we have heard much of the use of X-rays in the treatment of various skin diseases. In fact, Roentgen rays have played so prominent a part in surgery and medical work that we are apt to lose sight of their employment in other fields of useful service.

Just now popular interest in these rays has been attracted by their recent employment in testing the genuineness of old paintings. As explained in the February issue of the SCIENTIFIC AMERICAN MONTHLY, the paints of old masters, having a metallic base, are more opaque to X-rays than modern paints, which are largely made up of vegetable and aniline dyes, so that when a modern painting is subjected to X-ray examination it is practically transparent and throws no shadows on the photographic plate. Paintings, which have long been considered the works of old masters and which have been subjected to minute scrutiny by experts without betraying any evidences of fraud, have been shown under X-ray examination to have been of modern origin.

There are other recent uses of Roentgen rays which are of considerable importance in research work. For example, there is a method of chemical analysis by which it is possible to distinguish the constituent compounds in an unknown powder, by comparing a photograph of this powder with one containing known elements and compounds. X-rays have also been used recently in determining the nature of precious stones and in distinguishing between stones, by noting their phosphorescent luminescence under the Roentgen rays. (See article on page 227 entitled "Is Heliodor a New Gem?")

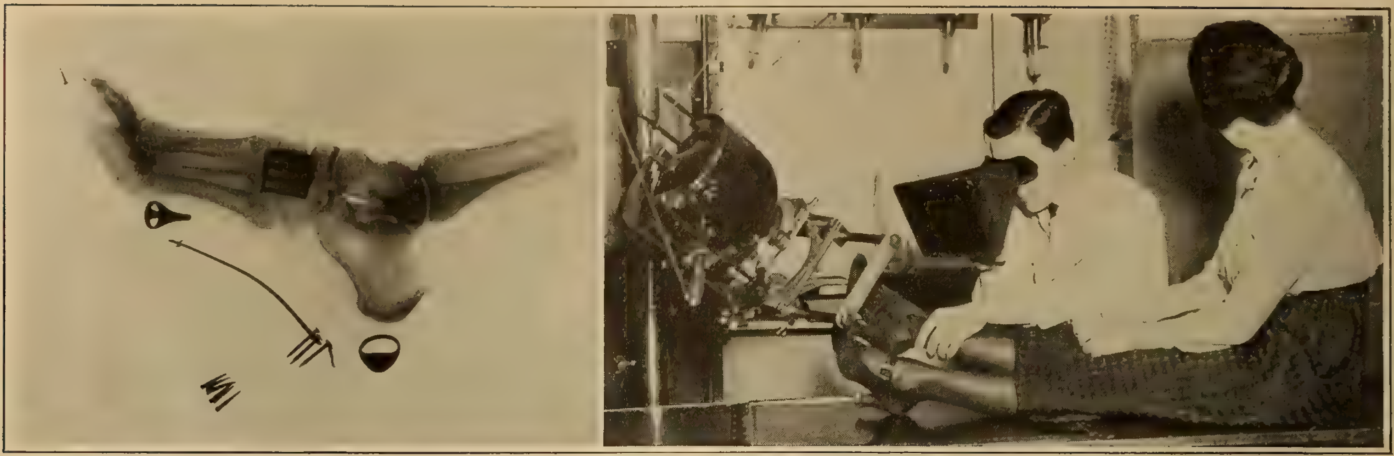
X-rays have been extensively employed for many years in detecting frauds, but as detective work must necessarily be veiled in secrecy, not much publicity has been given to this use of Roentgen rays.

During the war every effort was made to introduce contraband materials into Germany and if it had not been for the all-seeing eye of the Roentgen ray, it would have been impossible to prevent materials of the utmost importance to the enemy from reaching him by way of neutral countries. Efforts were repeatedly made to smuggle rubber and copper by burying them in bales or bundles of other materials. It would have been impossible to have made a minute investigation of every bale that was shipped, but by means of X-rays it was possible to see right through these bundles and packages and locate any substances that were more or less opaque to X-rays. Smuggling is extensively practiced in time of peace to avoid customs duties and for this reason wherever there is an occasion of suspecting a package, or even the wearing apparel of an individual, the X-ray machine is brought into service to search for hidden goods. One of our photographs shows a lady's shoe provided with a false sole in which two rings are embedded. X-rays have also proved useful in determining the nature of certain suspicious mail and express parcels. As shown in one of the illustrations, a harmless



TWO NOVEL USES OF ROENTGEN RAYS

In Fig. 1 a harmless looking parcel is being examined; Fig. 3 shows that it is really an infernal machine. In Fig. 2 oysters are being searched for pearls; the dark spot in one of the shells shown in Fig. 4 indicates a pearl



A SMUGGLER'S SHOE IN WHICH THE X-RAYS DISCLOSED TWO VALUABLE RINGS

looking package, on being subjected to the X-rays, proved to be an infernal machine of very ugly description.

A very novel use of Roentgen ray has recently been employed in Ceylon in order to search for pearls in oysters. Thousands of potentially valuable pearls have been lost to the world by the untimely opening of the oysters. Heretofore the pearl fisherman has had no way of telling whether an oyster contained a pearl of valuable size, or any pearl at all without opening the shell. In doing this, the oyster is liable to be killed and whether it contains a pearl of small size or no pearl at all, the fisherman must be content with what he finds. Were he able to see into the oyster without injuring it, he could pick out the bivalves containing large pearls and return the rest to the oyster beds. If they contained small pearls he could wait for them to grow to a goodly size. It is a simple matter to investigate a large number of oysters by means of X-rays and select only those which show large pearls, for pearls are opaque to the rays, and hence show as darks spots in the shell. By this means, much useless labor of opening shells is avoided and many pearl oysters are saved from untimely destruction and preserved for the growing of valuable pearls.

THE MECHANISM OF CHEMICAL ACTIONS CAUSED BY X-RAYS

THE experiments of C. T. R. Wilson proved definitely that the effects exerted upon matter through the absorption of X-rays are due solely to the corpuscular radiation which results therefrom. Fresh researches along this line made by the French physical chemist, M. A. Dauvillier, have recently been made and some of his conclusions were presented to the French Academy last fall, and are reported in the *Comptes Rendus* of that body for October 4, 1920. It occurred to M. Dauvillier that it might be possible to reduce the chemical phenomena which constitutes one of these effects, to a single type of reaction. He describes his researches as follows:

To begin with it is quite remarkable that the only mineral bodies which are sensitive to the action of these rays are those crystals concerning which it has been conceived and demonstrated by I. Langmuir, Born and Landé, Debye and Sherrer, that *they possess an ionic structure.* All other sensitive substances, including colloids, electrolytes, glasses, etc., likewise contain ions. It would appear from this that the cause of chemical action is to be found in the destruction of the negative ions, which are alone able to lose electrons, through the impact of the rapid electrons which constitute corpuscular radiation. The slow corpuscles expelled neutralize the positive ions in their vicinity and thus both electro-negative and electro-positive elements are set free in the atomic state. These produce coloration in solid or viscous substances, such as crystals and glasses, and actual chemical modifications in milieus within which they are mobile, such as electrolytes.

Let us consider from this point of view some of the more familiar reactions discovered by T. Villard: the violet coloration taken by alkaline glasses is due, according to this theory, not to an oxidation of the manganese but to a neutralization of positive ions with a liberation of the alkaline element in the atomic state, exactly in the same manner that a large number of crystals (sylvine fluorine, etc.) have a violet color imparted by the cathodic rays.

By means of this theory it is easy to explain the photo-electric properties of crystals and of colored glasses, and we can even understand their thermo-luminescence if we assume that there is produced (when they are heated to a certain critical temperature) a sudden thermo-electronic emission, beginning with the electro-positive atoms, with a consecutive ionization of the two types of free elements, and in consequence thereof an emission of light and a return to the initial state. We know, as a matter of fact, that under these conditions these substances lose their color and recover their power of becoming fluorescent. These phenomena cease to take place when the liberated element does not possess a sufficiently strong electro-positive character (chromium and the corundums transformed into rubies by X-rays or γ rays).

The brown color acquired under this influence by glasses containing lead is due in an analogous manner to the neutralization of Pb^{++} ions; the reduction of cupric silicate into cuprous silicate to the passage Cu^{++} ions into the C^{+} state; the Schwartz reaction to the transformation of mercurous ions, etc.

Levy has demonstrated (*Journal of Roentgen Society*, Vol. XII, 1916, p. 13) that the Villard effect is due to a destruction of a crystalline structure (without dehydration) of the stero-isomeric forms $Pt\ (CN)_4Ba4H_2O$. This question can be definitely answered only by a study of these crystals by the method of Debye and Sherrer. But we may assume that the ion Pt^{++} which is the most absorbent element of the crystal, is reduced to the state of atomic platinum, which produces the colorization.

As we know, this phenomenon, like all the chemical actions occasioned in crystals and glasses by the cathode rays, the β-rays, the γ-rays, the X-rays, and the ultra-violet rays, is accompanied with fluorescence, and that the light emitted possesses inversely the property of effecting the recombination. In my opinion this radiation operates no longer by means of corpuscles but quite *directly* and upon free *atoms* which alone are absorbent, producing a selective photoelectric effect which transforms them anew into ions. The free corpuscles are immediately fixed so as to reform the negative ions.

For example, when one exposes to light the platino-cyanide of barium colored by the X-rays, there is produced, starting with the atoms of platinum, a photo-electric effect which transforms them into positive ions, while the slow corpuscles expelled become fixed upon *the CN complexes which, in order*

to assume a stable electronic configuration in the crystalline space-lattice must exist there in the form of ions (CN^-).

The light will exhibit antagonistic properties only when the electro-positive element set free is photo-electrically sensitive in the spectrum of fluorescence of the solid or viscous medium.

According to this all the chemical properties of the radiations enumerated above must be considered as being due to the destructive action exerted upon the *negative ions* by corpuscles of a greater or less velocity (relation of the quantum), while the antagonistic properties of fluorescence (ultra-violet, visible, or infra-red) would be due to a photo-electric effect produced starting with normal *atoms*.

These reactions may be expressed by Perrin's equation:

$$\vec{Q} + P \rightarrow P' + \vec{Q'}$$

generalized by considering P and P′ to be the negative ion and the atom of the same electo-negative element; Q as the quantum given up to the ion through the reduction of velocity undergone by the rapid corpuscle; Q′ as that of the radiation of fluorescence equal to the work of ionization done by the atom P′.

Leonardo Da Vinci as an Inventor

Remarkable Achievements in Science and Invention of the Great Italian Artist

By A. A. Hopkins

AMONG the marking characteristics of the Renaissance—aside from a love of the antique world and an equally great devotion to the fine arts—were an unbounded curiosity, a thirst for fame, and a desire to develop and perfect the individual. This desire often resulted in men's engaging in many serious pursuits and studies which passed beyond the limits of dilettanteism. Leonardo da Vinci was a true son of the Renaissance in partaking of all these tendencies, and he was one of the few in all the race to whom it has been given to stand at one and the same time as the promoter and as the representative of a new civilization.

The materials for a definitive life of Leonardo are lacking; but from his manuscripts and sketches, and from the customary sources of information—documents both plastic and written—modern criticism with tireless patience has been enabled by synthesis to construct a tolerably accurate portrait of Leonardo the man, the artist, and the discoverer.

What astounds us most in reviewing the life work of this remarkable man is his versatility. Many of his predecessors had been so gifted that they could execute masterpieces in several of the arts, any one of which would have sufficed to make their author famous; many of his successors are so great that their achievements divide the suffrages of the world; but when universality of talents and effort are considered, all must stand aside in Leonardo's favor. He is not many-sided, he is all-sided—truly *"l'uomo universale."* During his lifetime (1452-1519) every human attainment was his, and nearly every honorable pursuit, barring the commercial, was followed by him with more or less success. He had a rare combination of gifts for an artist, uniting the artistic or creative, the mechanical or inventive, and the speculative. These first two phases of his personality are usually considered incompatible; but in Leonardo these prodigious faculties were nearly always maintained in perfect equilibrium; the artist and the savant did not displace each other. He was painter, sculptor, architect, poet, musician, philosopher, psychologist, author, critic, traveler, aeronaut, mathematician, physicist, chemist, geologist, mineralogist, zoölogist, botanist, geographer, meteorologist, astronomer, anatomist, physiologist, surveyor, topographer, engineer (civil, mechanical, mining, naval, and military), and inventor!

It must not be supposed that success always attended the results of this curious intellect's delving in the great storehouse of nature; on the contrary, he was often foiled, and many of his undertakings ended in failure. He was dreamy, procrastinating, a lover of courts, the lute, and improvisation; so that his temperament was largely responsible for his failure to execute or formulate works and theories which the brain had conceived. With fewer gifts, the harvest would perhaps have been greater. The real and apparent disorder in which he left the product of his meditations resulted in an ignoring of his real claim to be heard until the modern scholar cleared away the mists which surrounded his memory.

Though probably only a fraction of his writings and sketches have come down to us still they show that science had its renaissance in Italy one hundred years before Galileo. Leonardo was the connecting link between Archimedes and the modern world, and many of the discoveries which he made remained embalmed in masses of old papers, thus giving an opportunity for men of lesser caliber to rediscover these facts and give them to the world.

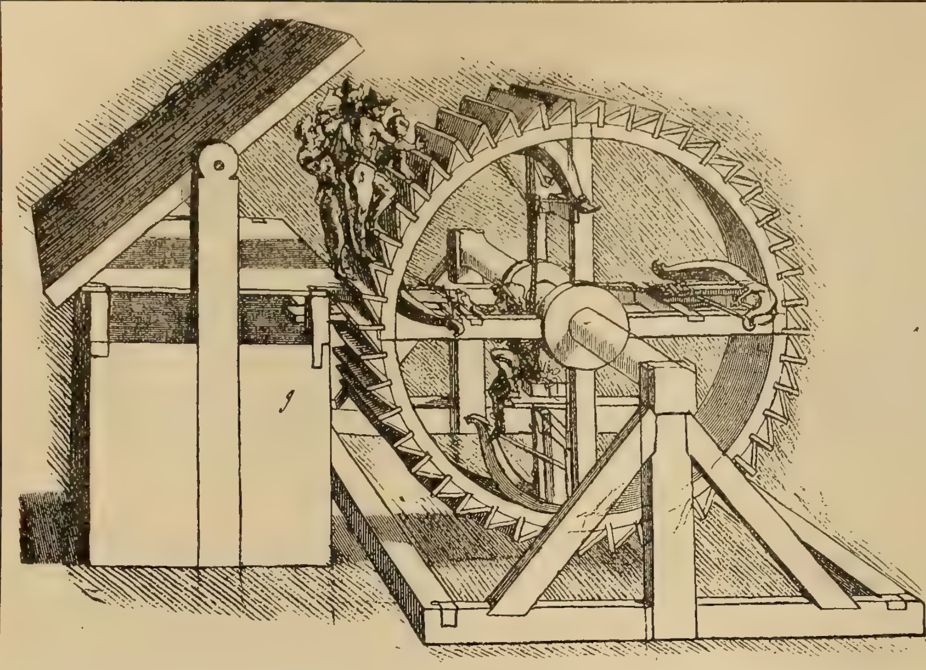
No other old master has left so many manuscripts; they consist of written memoranda with or without drawings, the latter often having no relation to the text. It is not strange when the encyclopædic nature of these writings is considered, that these manuscripts have been studied by specialists and societies of savants. The deciphering of these documents is rendered doubly difficult by Leonardo's extraordinary system of reversed writing; this matter has never been explained satisfactorily, as he wrote in the ordinary way when he chose. Still, from these bundles of old papers, the scholars who have studied them have found inedited chapter after chapter in the history of science.

Leonardo the artist—the painter, sculptor, and architect—does not come within the scope of the present article, which concerns only his scientific and mechanical achievements. It is but natural that a great thinker like him should have been fascinated and awed by the celestial world. He investigated the phenomena of the fixed stars and their luminosity. His pages concerning the moon bristle with original observations and ingenious theories. He accepted the spherical shape of the earth as an axiom; he believed also in the earth's rotation; and in a remarkable passage he says: "The sun does not move." He really forestalls Newton by indicating the universality of gravitation. He also knew of magnetic attraction, and the effect of the moon upon the tides.

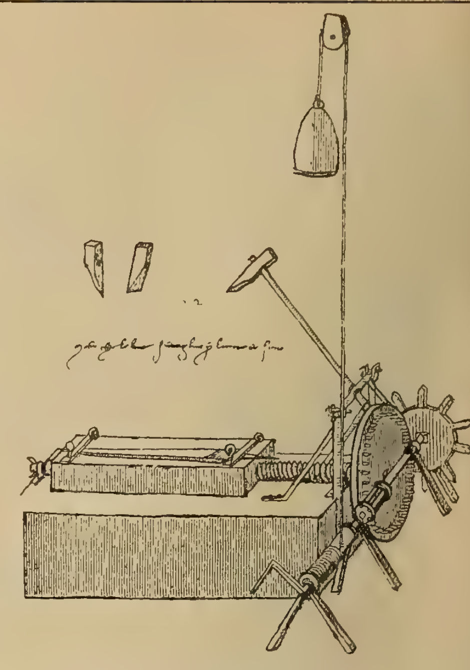
Leonardo was never tired of watching the clouds, and evidently meteorological phenomena had a fascination for him. He investigated the structure of hail, and invented the hygrometer. He also constructed instruments for measuring the flow of water and the speed of vessels.

The geological and physiographic problems of the history of our globe interested him. He seems to have had the correct theory of the elevation of continents and the true nature of fossil shells. The bulk of his writings on geography are devoted to water. He shows the true scientific spirit here, as elsewhere, in exhibiting patience and a reserve in dealing with facts which he has not himself observed.

Living as he did in the beautiful Val d' Arno with his myriads of wild flowers, it is little wonder that botanical questions should have attracted Leonardo. He collected plants, dried and pressed them; he established herbaria, and devised a method of obtaining leaf-prints which is in use today. His drawings of flowers and leaves are very numerous, and are of scientific accuracy. He studied vegetable physiology, the laws which determine the existence and multiplication of



MILITARY ENGINE DESIGNED BY LEONARDO, FORERUNNER OF THE MITRAILLEUSE



LEONARDO'S INGENIOUS FILE CUTTING MACHINE

plants. Long before the time of Grew and Malpighi he had discovered that it is possible to determine the age of a tree by means of its rings.

Vasari states that Leonardo studied anatomy under Marco Antonio delia Torre; and Leonardo's writings and drawings show that in the history of medicine he deserves a high place, his work bearing the stamp of much originality, as his drawings of anatomical subjects are ages removed from those in the medical works of his time. We have even reason to believe that he was acquainted with the circulation of the blood. He was the founder of the science of comparative anatomy; for, being struck with the analogies of the same organs in various animals, he proposed to make a systematic study of them, beginning with man, then the ape, etc. His studies led him to the unique conclusion that man is a quadruped, as the child walks on hands and feet!

He made great progress in mathematics and natural philosophy; we know that he was proficient enough in the former to assist the eminent mathematician, Paccioli. He is rather doubtfully accredited with the invention of the algebraical signs + and —. He calculated the method of finding the center of gravity of pyramids. He restored the laws of the lever; he knew the laws of impact and of friction, and the principle of virtual velocities; and he studied the time of the descent of bodies down inclined planes and circular arcs. He foreshadowed the undulatory theory of light and heat, applying the laws which govern the motion of waves to the theory of optics and acoustics.

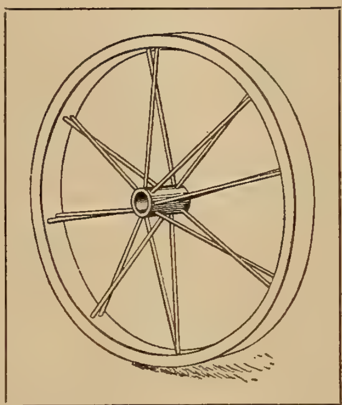
His famous "Treatise on Painting" is filled with remarkable sketches showing that he was familiar with the laws of light. It is believed by some critics that he invented the "camera obscura." It is thought that he divined the true action of the eye, the movement of the iris, and the duration of the image on the retina. He was acquainted with the facts of combustion and respiration. We owe the modern lamp chimney to him, as well as the glass water globes which are used to encircle lamps. He made curious figures out of the intestines of animals and filled them with heated air, so that they rose quickly; here was the germ of the Montgolfier balloon. Leonardo is believed to have surmised the molecular composition of water. He also devised terrible Greek fires.

Leonardo the engineer and inventor will have have a special interest to those who live in this inventive age. The rude tools of the laborer which were used by the men that Leonardo employed in carrying out his undertakings, exasperated him; and he made every effort to devise labor-saving inventions. Unfortunately, we do not know to what extent these various inventions were adopted. The position of a machine in the time of Leonardo was curious. In the petty cities and republics, machinery was the property of the State; and to betray its construction was a crime of *lèse-cite*, punishable by death. Rulers even declared wars in order to obtain the secret of a new industry; so it is little wonder that a genius like Leonardo should have been coveted by sovereigns.

In civil engineering Leonardo was so proficient that he was employed by such rulers as Cæsar Borgia. He understood the boring of tunnels and the cutting of canals, devising ingenious excavators which embanked the earth taken from the cutting. His arrangements of derricks, pulleys, screwjacks, and rolling cranes were of great interest. The obelisks in London and New York were set upright by the same means which Leonardo employed to raise a column. We possess a project by him for lifting up the Baptistry of Florence en masse and setting it on a new foundation. Bronze-casting he was also acquainted with, including piece-molding, while he had a rare knowledge of the physical properties of both metals and alloys. The few fragments on the resistance of beams which remain to us show that he was deeply versed in what we fondly consider a new science—the "strength of materials."

All his life long Leonardo seemed to be interested in water, which he describes as the "great carrier of nature." The drainage of marshes by siphons, the irrigation of land, the dredging of rivers and harbors by a rotary bucket-dredge, were planned out with infinite care for details. He devised ways for making useful a stream not navigable either by reason of too slight a depth or from liability of failure in time of drought. He proposed a series of diagonal dams with locks at the angle. Similar methods are today used on the Marne, the Seine, and other rivers. His plan for rendering the Arno navigable was rejected with scorn, but was carried out two hundred years later. He invented all kinds of water wheels, undershot, overshot, and breast; some of his wheels were placed horizontally, and the idea of the Fourneyron turbine originated with him. His schemes for raising water from a lower to a higher level are numerous and interesting and some of them are in use today. He also made sketches of swimming-machines, and he devised the precursor of the modern pneumatic life-preserver.

The stone-saw invented by Leonardo rendered quarrymen independent of natural cleavage, and saved untold time in smoothing. A similar saw is now in use at Carrara. Of the stone-saw we have over thirty rough sketches before the perspective drawing of the machine, shown in our engraving, was made. He was the true engineer, dashing off his ideas roughly at first, and afterward elaborating the machine in all its details. The file cutting machine is one of the most remarkable of his inventions. It was entirely automatic, power being provided by the descent of a weight. The file was held in place by clamps on a movable bed which brought the blank under the hammer, which delivered its blows by a tripping mechanism. A very similar machine is at present employed for the same purpose. He also designed a machine for boring out wooden pipes, as well as a saw for wood. His metal-planer does not seem to have been successful, though he had the correct idea. His rope-making machine possesses positive merit, while his drop forge press, door-spring, color-grinder, chimney-hood, odometer, nap-shearing machine, loom-calculations for textiles, and spinning machinery, are all remarkable. The suspension wheel invented by Leonardo is used today in the bicycle and automobile. It was a great improvement over the old "compression" wheel, the load carried upon the axle being suspended from the rim instead of being supported on the spokes which fall beneath the axle. The roasting jack which turns automatically by means of heated air is also due to him. His studies on windmills are very interesting.


LEONARDO'S SUSPENSION WHEEL

Leonardo was undoubtedly the first aeronautical engineer and he may be regarded as an inventor of the helicopter and also of the basic flying machine, particularly of the one by which Lilienthal met his death. The treatment of this subject will be deferred to a later issue of the SCIENTIFIC AMERICAN MONTHLY, when it will be adequately treated with a number of highly interesting illustrations.

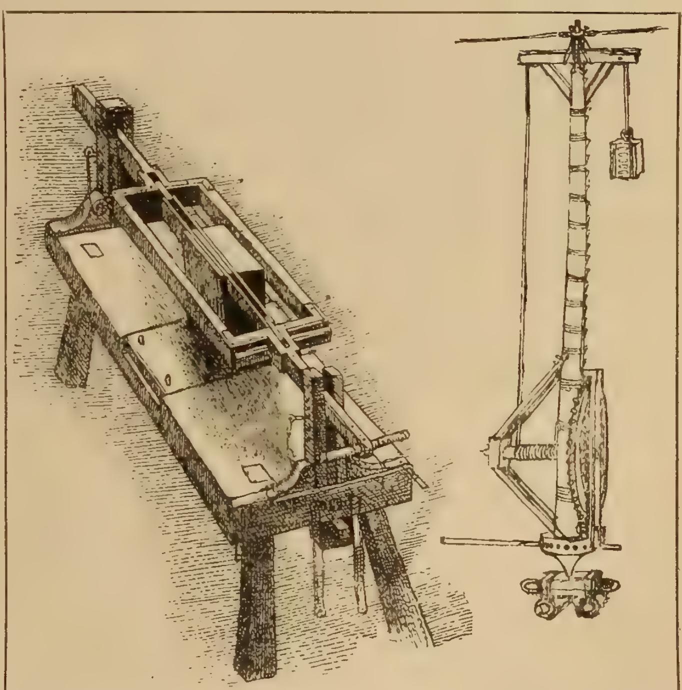
As a naval and military engineer Leonardo was truly terrible. In the memorable letter intended for the Duke of Milan, which is one of the curiosities of the Renaissance, he describes the various engines of war which he could fabricate, and the means by which he could overcome the enemy. Leonardo has left hundreds of sketches of catapults, ballista, gigantic cross-bows, breech-loading cannon, mitrailleuses, serpentine organs, and steam cannon. The breech-loading cannon antedated Leonardo, though he made substantial improvements in it. He devised breech-loading mitrailleuses for giving both a parallel and a fan-shaped fire. He it was who discovered the secret of the conical rifle-ball. The steam cannon invented by him consisted of a copper tube one-third of which was subjected to fire contained in an open basket. When the breech was very hot, water was introduced into the barrel; it was instantly vaporized, discharging the projectile with great force. The Serpollet boiler of today is built on the same plan. When it is said that Leonardo understood the principles of the very modern "built-up" gun, it may well be said that this might be called his greatest title to fame as an inventor. He has left minute sketches of guns reinforced by hoops shrunk on, of guns composed of sections welded on, and of wire guns. The latter are the most interesting. In Leonardo's designs the reel is shown around which the wire is wound. He also devised special machinery for drawing the metallic tape for use on the gun exactly to gage.

The brain whirls when the achievements of this remarkable man are reviewed. It is little wonder that the men of his time considered that there was something uncanny about him. It is not strange that Vasari should have used the word "divine" in speaking of him. Notwithstanding his performances in all the arts and sciences, he seems to have considered painting as his chief occupation in life. The artist-critic, Mr. Edwin H. Blashfield, expressed the thought with rare felicity when he wrote: "A man who had the whole book of nature open before him as the subject of his commentary, could leave a miniature here and there at most. His art was only the rubrication which made the text fairer to look at." It is perhaps fortunate that we, with our twentieth-century pride in recent victories of science, art, and invention, can look back four hundred years to the century of the "discovery of man," and see in the colossal form of Leonardo da Vinci the very incarnation of the aims and ends of the Renaissance, the springtime of the modern world.

TURNING LOSSES TO PROFITS

FORREST CRISSEY is the author of a little book entitled, "Laboratories That Turn Losses to Profits," and in it we find numerous examples of how laboratories have been able to accomplish this desirable purpose. Having often heard sarcastic comment on the small percentages of substances sometimes reported by a careful analyst, these being frequently regarded by the layman as unimportant, we cite two examples given by Mr. Crissey to emphasize again the real importance of traces.

On one occasion a dealer in molasses desired to please a distributing house and so substituted a better and more expensive grade of molasses for one specified in a shipment which was to go to Newfoundland. Much to his surprise there was a great complaint from the consumers and an investigation was started. It seems that in Newfoundland molasses at that time was largely used for sweetening tea and they had been in the habit of buying molasses from Barbadoes where it is customary to employ only copper kettles in its manufacture. The dealer had substituted a finer quality of molasses from New Orleans and in Louisiana it is customary to boil molasses in iron kettles. Now when the merest trace of iron comes in contact with tannin a black precipitate forms, so when the users of the New Orleans molasses in Newfoundland sweetened their tea it turned black. There


MARBLE SAWING MACHINE TRAVELING CRANE

was no more than a trace of iron, but it was sufficient to do the damage.

Again an American manufacturer found it necessary to obtain manganese dioxime from a new source in order to fill a European order for dry batteries. Ordinarily the ore used comes from Russia and contains 80 or more per cent of manganese and one per cent or less of iron. An ore in South America was found which met this specification and was used in one million dry batteries which tested satisfactorily before shipment. Before long, however, the manufacturer received complaints and the European customer returned the shipment. Meanwhile the ore was subjected to a very careful analysis and found to contain from ten to fifteen one-hundredths of one per cent of copper. This copper was enough to do the damage for it had formed a delicate film over the zinc causing resistance to be increased to the point where the full electromotive force expected could not be delivered.

The little book is interestingly written and affords good reading to him who may still doubt the practicability of putting science on his payroll.

THE OIL SHALE INDUSTRY

Those who have been interested in the development of the oil shale industry would do well to read the article, "Problems of the Oil Shale Industry" by the state geologist of Colorado, R. D. George, in the December issue of *Chemical Age* (New York). In the January issue of the same publication there is a summary of the commercial development of chemical engineering in shale oil recovery which should be reviewed at the same time. This summary gives the names of the processes of which there are seventeen, and then continues with such details as the name of the owner with address, the type of material of construction, method of advancing shale through the retort, the through-put in twenty-four hours, dimensions of retorts, the type of feed, and of discharge, the size of shale treated, the nature and method of applying the fuel used, the temperature required in the various zones of the retort, method of withdrawing the gas and oil vapors during the process, when and how steam is used in the process, the present stage of the development of the process in each instance, and notes on special features. This summary affords a good opportunity for carefully comparing the different processes that have been brought out and for which in some instances support has been sought.

In discussing the problems of the oil shale industry, Professor George takes up the problem of retorting under five principal heads. These are:

"1. To convert as much as possible of the oil-making material of the shale into oil or other useful products.

"2. To secure a crude oil containing the largest possible percentage of the most valuable constituents, such as gasoline, keresene and lubricating oils, and the smallest possible percentage of worthless and harmful materials which must be removed as waste in refining.

"3. To secure a crude oil which is easily fractionated into gasoline, kerosene, lubricating oils and others, and which yields fractions of cuts which are easily refined.

"4. To secure as large a yield of ammonia and other valuable by-products as possible without sacrificing more desirable results.

"5. To reach the highest commercial efficiency without sacrificing the raw materials of the company or of the country."

After discussing these problems at some length he takes up those of refining and of by-products. Since a strong point is always made with reference to the by-products of the industry, the following is quoted from the article under discussion:

"Other By products.

"Much nonsense has been written about the many valuable by-products of oil shales. It is true that many commercial products can be made from the shales, but most of those commonly listed can be made more cheaply from other forms of raw materials. This is true of dyestuffs, medicinal salts and many other chemical substances.

"A substance resembling ichthyol has been made, but it is very doubtful that true ichthyol has been produced.

"Synthetic rubber has been much talked of but it is safe to say that nothing approaching a commercial process or a commercial quantity has been discovered.

"A substance resembling gilsonite and possibly suitable for a rubber filler may be separated from the tarry residues.

"Paraffin wax of high grade and readily marketable may be produced in commercial amount and profitably.

"Analyses of several samples of spent shale showed an average potash content of eighteen pounds per ton of spent shale. This is water-soluble, and could be leached out at little cost.

"The spent shale has been proclaimed a fertilizer, but it contains nothing of value in this way except the potash and it would be absurd to list it with fertilizers.

"It has also been talked of as raw cement material, and as brick material. It is of less than average value for either of these purposes.

"One advertiser of shale oil stock has found that it is the best of material for glass and porcelain making. This is nonsense.

"It is not even good road material and its disposition will present a problem.

"The tars, still carbons, or coke and the heavy residual oils will be utilized about the plants or converted into marketable products.

"Lubricating oils of the highest grade are made from the Scottish shale oils, and laboratory quantities of lubricating oils made from Colorado shale oils have been given extraordinary results when tested in actual use. They retain their viscosity or body at much higher temperatures than do oils of similar density and flash point made from well petroleum.

"Much information is being given out regarding the precious metal content of the spent shales. A large number of assays by thoroughly reliable and competent chemists and assayers, have failed to give a single return which could by any reasonable means be called commercial. Traces of gold were found in possibly one-half of the twenty-two tests made by the Colorado Geological Survey."

THE CRYSTAL STRUCTURE OF ICE

In *Science* for September 24th 1920, Mr. D. M. Dennison of the Research Laboratory of the General Electric Company at Schenectady, makes a brief statement of the results of investigations on the crystal structure of ice.

X-ray photographs of ice were taken to determine its crystal structure following the method used by A. W. Hull. The lines on the film correspond to those of the hexagonal system. They show that ice has a lattice which is built up of two sets of right, triangular prisms interpenetrating one another in the following way. Consider the plane containing the bases of one of the sets of prisms. The molecules lie at the vertices of equilateral triangles of side 4.52 Ångströms. At a distance of 3.66 Ångströms above this plane lies the plane containing the bases of the second set of prisms. Here the molecules also lie at the vertices of equilateral triangles equal to those of the first set, but each molecule is situated directly above the center of one of the lower triangles. The other molecules of the crystal will lie directly above the molecules of the two planes just described at intervals of 7.32 Ångströms. The above values give an axial ratio of 1.62 in good agreement with the crystallographer's value of 1.617. From these data the number of molecules at each point has been calculated to be two.

This means that the molecule of ice must be of the form $(H_2O)_2$ or H_4O_2. The full data and calculations will be published in the *Physical Review*.

Science and National Progress

Edited by a Committee of the National Research Council

Dr. Vernon Kellogg, Chairman, Dr. R. M. Yerkes, H. E. Howe

The National Research Council is a cooperative organization of the scientific men of America. It is established under the auspices of the National Academy of Sciences and its membership is largely composed of appointed representatives of the major scientific and technical societies of the country. Its purposes are the promotion of scientific research and of the application and dissemination of scientific knowledge for the benefit of the national strength and well-being.

TROPICAL FORESTS

By H. N. Whitford

Yale School of Forestry

The world contains two great forest belts, the one in the north temperate zone and the other in the tropics. Both are interrupted in their continuity by grasslands, deserts and oceans. The one to the north, because of its great change of seasons, has but a part time capacity for productivity. It means that Nature's great wood manufacturing laboratory is running only half time. In the tropical belt, midway between the poles, where the wood manufacturing plant runs the year round, the capacity to grow timber per unit of area is theoretically twice that of the northern belt.

In past geological ages, due to changes in climate, the torrid zone with its existing forest vegetation has spread toward the poles; at other times the north temperate forests have been pushed toward the equator at the expense of tropical vegetation. It was at the beginning of the glacial epoch that the progenitor of man was supposed to have found himself in a different environment from that of his native tropical forest. He must change his habits or perish. Primitive man was the result. During the whole Pleistocene epoch, with its four distinct glacial and interglacial periods, mankind spread to the four corners of the globe. It is only since the last ice sheet that primitive civilization arose in central Asia. It spread to many parts of the globe. In its westward movements it found an environment favorable to its rapid development in western Europe and later, North America, and what we call modern civilization came into being.

In the spread of primitive civilization it has encountered certain natural obstacles in its way. These are the desert, the mountains, the forest, the sea, and the rigors of winter. It was the overcoming of these obstacles that increased man's brain power and has resulted in our modern civilization.

In this struggle the forests, at first an obstacle, have played no small part. Their products furnished fire wood for cooking purposes and timber to build houses and minimized the rigors of winter. They supplied the materials that built the ships that conquered the seas, the highways of the world. One need not enumerate the thousands of uses to which forest products today are put. In spite of the many substitutes for wood the per capita consumption is increasing. Naturally the forests nearest at hand, or those of the north temperate zone are the ones that have been most drawn on. Each successive virgin forest has been attacked, destroyed, or badly damaged and the operations transferred to another place. In western Europe the virgin forest has disappeared. Planted or well managed second growth forests have taken their place. In the United States of the original 820 millions of acres on which nature's chemical wood factory had produced stocks of timber ready for the axe, but 463 million acres are left. Of this amount 137 million acres or 1/6 of the original area is virgin forest, 80 million acres is unproductive waste. More than half of the remainder is small timber of inferior quality.

Nature's wood chemical laboratory needs to be protected against the further ravages of man. It has been so badly damaged that it will take many years for its recovery. Especially is this true in the eastern part of the United States where there is a shortage of wood already. Even if the severe measures advocated by the most radical forest economists were put in effect tomorrow, it would be many years before timber could be utilized. Certain of our industries, some of them basic, that depend in part or wholly upon forest products, are feeling the shortage of raw materials. The average citizen feels it in the much higher prices he has to pay for everything made of wood.

It is known that the vast areas in the tropics are covered with forests. Do these forests contain wood products that will aid materially in the further development of our modern industrial civilization? This question has been answered pro and con. But the answer either way has not been satisfactory because much investigation is necessary before the truth can be known.

It is true that the wood products of the tropics have played only a very small part in our economic life of today. Statistics for 1913 show that not much more than 150 million board-feet reached the United States from tropical countries. More than half is classified as mahogany and Spanish cedar, and much of the remainder are cabinet woods of various kinds. On the other hand, until recently, the northern belt of forests ships annually more than ten times this amount or number, mostly construction timbers, to tropical countries. There is no tropical country that has an industrial development worthy of the name, but has been the recipient of the products of our forests. This has led some forest economists to the belief that tropical forests contain nothing but hard, heavy woods suitable only for cabinet work or furniture manufacture or for other special uses that do not need large quantities of timber. Where investigations have been made, as in the Philippines and British North Borneo, this has been proven not to be the case. On the other hand, these investigations show the forests are more abundantly supplied with soft hardwoods that can and are being substituted for the same uses to which the pines and oaks were formerly put. It has been estimated that in the Indo Malay region there are about 1,600 billion feet of standing timber ready for the axe, or about the estimated amount that is contained in our Pacific Northwest.

The area of standing timber in the Amazon Valley is estimated to be over one billion acres, or more than twice the forested area of the United States. Before the writer had seen the forests of the coastal region of Dutch Guiana and the coastal region of Brazil, he estimated the stand of timber in the Amazon Valley to be 3,400 billion feet or 600 billion feet more than is contained in the United States. He now believes that estimate is too low and that the figures given are ultra conservative. In tropical America besides the Amazon region, in Brazil, in the Guianas, Colombia, Venezuela, Central America, southern Mexico and in Paraguay and neighboring parts of northern Argentina there are large areas of forests. The Belgian Congo region alone is estimated to contain 448 million acres of forests of one kind or another. With the exception of a comparatively few woods that reach our markets and those of Europe, usually the gold nuggets of the forest, we know little about the capacity of these forests to produce timber for the more general use of industrial civilization.

One of the first steps to gain the required information is a

knowledge of the forest flora of these regions. Much progress has been made in the classification of the forest flora in the colonial possessions of the United States and European nations. Especially is this true of India and the Philippines, the Dutch East Indies, some colonial possessions of Africa and elsewhere. Some progress has been made in tropical America. The first fascicle of a publication entitled "The Trees and Shrubs of Mexico," has recently been published. The West Indies and parts of Central America have been fairly well combed in a general botanical way. Recently a combination of three of our largest herbaria has undertaken to direct its attention to northern South America. Our herbaria contain much material that needs to be worked up, but the corps of trained men is far from being adequate. The systematic botanists of our country should be encouraged in every way possible to continue the work already begun.

While systematic work is necessary for an understanding of the composition of the forest, yet this is only a classification of the forest composition from a qualitative standpoint. A quantitative as well as a qualitative analysis of the forest is necessary to know its economic value. Because we have depended on the former rather than the latter studies of tropical forests, a widespread misconception of their nature and economic importance is current. It is interesting to know that in the Philippines there have already been classified 2,600 tree species in an area of 120,000 square miles, or about three times as many as are found in the whole of the United States, distributed over an area of more than three million square miles. Yet from an economic standpoint it is much more important to know that more than one-half the standing timber of the Philippines is composed of less than 20 species and that when the lumber of these is put on the market for general use they fall into three groups, one a group of hard durable timbers for construction work in contact with the ground, another, moderately hard non-durable timbers for heavy construction work not in contact with the ground, and a third group, by far the most abundant, composed of comparatively soft non-durable timbers that are being used for light construction work. It is true that sometimes the wood of a particular species of any one of these groups is preferred for special uses. Before it can be stated that similar conditions exist in the virgin forests of the American and African tropics more extensive studies are necessary. Indications point to the fact that the composition of the upper story or two upper stories of the forest, and these are the stories that contain trees of merchantable size, are more complex than those of the Philippines, but much simpler than a census of the trees of all the stories of a given tract would show. Thus, published accounts of a census of forests made in British Guiana show that in one type of forests covering large areas three species formed 45.7 per cent of the trees; 7 species, 61 per cent. In another type one genus and two species formed 42.8 per cent of all the trees. Still other types showed similar conditions. These studies were based on counts by diameters and not by volumes. Had an estimate been made by volume it is believed that the percentage of the leading species would have been higher. The writer has had an opportunity to make detailed studies for limited areas in two places in the American tropics. In one case 90 per cent of the timber of merchantable size was of one species, a hard, heavy wood suitable for ties. This was in a dry region and the amount per acre was light. In another region in one type 100 per cent of the timber reaching merchantable size was of one species—a soft hardwood. On the property examined there were 8,000 acres in this type and the stand would average 25,000 board-feet to the acre, in some places 60,000 to 70,000. This is exceptional, however. In an adjoining type, which because of lack of time was not studied in detail, perhaps 8 or 10 species would yield 60 or 70 per cent of the cut with the stand per acre much lower. Cursory examinations in other parts of the American tropics show conditions similar to the last. These examinations are not extensive enough to make general conclusions.

The above is given to show the necessity of investigation. Expeditions to carry on the work could well be confined for the present to the more accessible areas. The personnel composing them should be equipped to collect botanical material including wood samples, to map the areas covered and roughly estimate the amount of timber by kinds. Especial attention should be paid to the woods known in the local markets and to those species that are most abundant whether or not they are known to be of use. All forest products other than woods should be studied and samples collected.

Another line of investigative work is the classification of the woods. Good work has been done on the woods of India, the Philippines, Java and other colonial possessions in the tropics. While some progress has been made in the American tropics, the field for study has hardly been touched. One institution in the United States has undertaken this work, but because of lack of financial support the progress is slow. The importance of this work will become apparent when it is stated that there are numerous requests for identification of tropical woods that have entered our markets. There are requests also for information concerning tropical substitutes for many of our own woods that certain industries depend upon. These requests are made because such industries are getting anxious about the future source of supplies.

While our modern industrial civilization has depended on the tropics for its woods de luxe only and has furnished their people with a considerable supply of their construction timbers, it has gone to tropical forests for other classes of products that have become indispensable to some of its basic industries. Aided by the increased energy of the tropical sun, nature's chemical laboratory is able to produce, besides wood, a greater abundance of certain by-products than is possible for its less energetic competitor in temperate climates to do.

Thus modern civilization today is depending on the tropics for rubber and its allies gutta percha, balata and chicle. Resin-like substances, oils dye woods and tannin products play an important part in our arts and sciences.

The products of tropical palms play an important part in our everyday life. The soap with which we take our bath may contain palm oil. We may put on a coat that has buttons made of the nuts of the ivory palm. The hat we wear may be made of the fibers of the Panama palm. Some ingredients of the explosives we used to help win the war may have come from a palm, and the best charcoal used in the gas masks that protected our men on the battlefield may have been obtained from the shells of several species of palm nuts. The candles we burn may be made of the wax taken from the leaf of a palm. The rattan chairs we sit on and the canes we carry may have come from climbing palms that grow in a tropical forest. The mattress we sleep on may be made of kapoc, the product of the fruit of the silk cotton tree. We are dependent on the tropics for such important medicines as quinine, ipecac, and a host of others used in pharmaceutical science.

Only a few of the hundreds of different kinds of products which the people that live in or near tropical forests make use of in their daily lives, reach our markets. Many do not reach the local markets. As they are better known they may become an article of local trade and then ultimately reach the world's markets. The history of the discovery of many of the products and their introduction into our markets reads like a romance.

Most of the raw materials from which the articles cited above are made are still gathered in virgin forests. One by one as the articles become more essential to our modern civilization, experiments are made to test the possibilities of their being raised profitably as cultivated crops. Take the case of Para rubber for instance. In its native home, the Amazon River, the trees grow far apart and the cost of collecting is great. Our knowledge of the existence of rubber dates back to the discovery of America by Columbus who is said to have seen natives playing with rubber balls in the island of

Haiti. It was first used, long after, to remove pencil marks. Later the Mackintosh firm began to manufacture waterproof coats, but it was not until after 1839, when Goodyear discovered the process of vulcanizing it, that the Mackintosh waterproof coats came into more general use. The British Government, ever keen to get valuable products growing under its own flag, encouraged its introduction into the Ceylon in 1876 and cuttings from these plants were distributed to other parts of the British empire throughout the tropics. It was not however until the first decade of this century when the automobile industry began to demand large quantities that commercial plantations were established. In 1910 the world's production of rubber was 68,200 tons, 12 per cent from plantation rubber. In 1920 it is estimated to be over 300,000 tons, 90 per cent of which is from planted rubber and most of this from the Federated Malay States and neighboring regions, one of which is Sumatra. It is here that American capital has made its investments under Dutch control. While much investigation has been made in increasing the productivity of rubber trees in plantations, research problems in the management of the cultural forests to give maximum results are still in progress.

Of importance to us as a nation is the possibility of extending the growing of Para rubber nearer home. Plantations in various parts of the American tropics exist but so far generally have not been successful. Investigation work here is of prime necessity. It involves research work in the methods of protection against a disease that is present only in the American tropics.

Because of political control and economic conditions connected with supplies of labor, European nations have introduced other forest products whose native home is in the American tropics, into their eastern colonies. Among these are the cultivation of the Cinchona tree (quinine) and the silk cotton tree (kapoc). Thus today Java produces most of our quinine and nearly all the kapoc.

The writer cannot leave the subject of Tropical Forests without a word concerning the possibilities of the tropics for growing crops of trees for their timber and its by-products such as cellulose. In the production of wood supplies, the English in British India and to a less extent the Dutch in Java have made advances. The British, not content with managing their valuable natural forests which contain teak to yield continuous supplies of timber, have planted large areas which are yielding returns. The Dutch also have extensive forest areas planted in teak. Experiments in teak planting are under way in other British tropical colonies in Trinidad and West Africa especially. This includes experimental plantations of such valuable woods as mahogany and Spanish cedar and others.

While much research in rapidity of growth of planted tropical trees and other plants has been made, and indicate that crops of timber will reach maturity in a much shorter time than in our own climate, much investigation is necessary before the exact time it will take to raise such crops on a commercial scale can be determined. That there is great variation in the rapidity of growth according to the species and to the nature of the habitat is true for the tropics as well as for temperate regions. Measurements made recently in virgin forests of the Philippines indicate that the annual increment per year is 1.91 per cent of the mature stand. It has been estimated that the annual growth in our southern pine forests is one per cent of the mature stock on hand. If these estimates are correct it means that the tropical sun has annually somewhere near twice the capacity to store up energy in the form of wood, than does the temperate sun. To put it in another way, one acre of ground can grow as much timber in a year in the tropics as two acres in the colder climate.

The above-mentioned estimates were made in the dense forest and show that the large trees have a much more retarded growth in their younger stages than do many of our own species in our climate. It is only when they reach the middle and upper layers of the forest that they overtake and pass in rapidity in growth many of our own species. Estimates in growth on the same species in the forest and in the open show that in the forest it takes about twice as long to reach a diameter of 12 inches as it does in the open.

The same investigator made measurements in the second growth forests and compared them with the average growth of a large number of species in the United States. This shows that it takes our species on an average of 68 years to reach a diameter of 14 inches, whereas the Philippine species measured reached the same diameter in 17 years. According to recent investigations made by Dr. Rowlee in the rich bottom fruit lands of Central America, crops of timber of balsa wood averaging 20,000 board-feet per acre can be raised in five years. In the Mississippi Valley, it takes cottonwood, our fastest growing hardwood, 30 years to yield the same amount of lumber. The above examples are given because the forest of the tropics contain many soft wood species whose specific gravity is about that of spruce and white pine. Some of these occur in pure or almost pure stands on cut-over lands and reach maturity in 15 to 20 years. Others occur in virgin forests, and in certain habitats constitute the bulk of the stands, in one case at least, all of the stand over limited areas. They reach huge dimensions, six feet and over in diameter, 150 to 200 feet in height. The indications are that they attain maturity in 75 to 100 years or less.

If investigation should show that one or more of the many kinds should prove suitable for paper pulp, crops of timber could be raised in one-fourth to one-third the time that it takes to produce a similar crop of spruce in our temperate regions.

In the above there has been an attempt to bring together a few of the facts concerning tropical forests, the extent to which they are used, and their rate of growth. Our knowledge concerning the possible uses to which many of their products could be put is limited. Much pioneer investigation along the lines suggested above is needed before we can answer many questions. The tropical sun has stored up energy in the form of wood and other products that are today little used. It is shown that it has the power per unit of area to produce annually two or more times as much of this form of energy as the temperate sun. Modern civilization has used a great deal of this form of energy to aid its development. Believing it had unlimited supplies it has wasted more than it has used and is now making strenuous efforts to conserve the remaining supplies nearest at hand. This is good economic common sense and every effort possible should be made to encourage the better conservation of our forests, but the damage has been so great that long before we can bring them back to proper management, many of our industries will suffer. Our nearest source of outside supplies is the American tropics. Hence the need of investigations along the lines suggested above.

The economic conditions associated with the exploitation and cultivation of tropical forest products are admittedly not the best. The people of our modern civilization have a fear of the tropics. Their Simian ancestors were held in bondage by them until climatic changes forced them to change their habits. Modern civilization in its development has brought under control many of the forces of nature of the temperate regions of the world. It is only when it felt the need of products which it could not find near at hand that it has gone into the tropics.

After all, the dangers of the tropics is not so much in the climate as such, but in the diseases that it breeds. The sanitation work done in the building of the Panama Canal alone proves this. There have been many other less advertised cleaning-up operations on not so large a scale that strengthen the proof. Witness the work done by colonial governments in sanitation, the Americans in the Philippine Islands, the British and Dutch in many parts of the tropical world. Very significant is the work accomplished under the Brazilian govern-

ment in making sanitary the principal cities that were subject to serious outbreaks of yellow fever and other diseases. Many private concerns, realizing that success on a large scale could not be obtained, have their physicians and sanitary engineers. The Rockefeller Foundation has undertaken the task of making yellow fever a historical disease and has done much work in many parts of the tropics in controlling other diseases, such as malaria and the hook worm. This work shows conclusively that nature's forces in the tropics can be controlled, and the day is at hand when the economic resources of the forests can be more fully utilized to serve our increasing wants.

Notes on Science in America

Abstracts of Current Literature

Prepared by Edward Gleason Spaulding, Professor of Philosophy, Princeton University

FACTORS CONTROLLING DISTRIBUTION OF FOREST TYPES

MR. G. A. PEARSON, Forest Examiner of the Fort Valley Forest Experiment Station, presents in two extensive papers published in *Ecology* for July and October, 1920, an account of his investigations on Factors Controlling Distribution of Forest Types. The following is a summary of Mr. Pearson's results and conclusions:

1. Air temperature in the San Francisco Mountain region decreases rather uniformly with a rise in altitude excepting for local inversions in the minimum which occur between the yellow pine and the Douglas fir types, due to air drainage. The lowest absolute minima and the shortest frostless season occur in the yellow pine type, following closely by the alpine type. The highest temperatures and greatest duration of high temperatures are found in the lowest altitudes. Maximum temperatures decrease uniformly from the lowest to the highest stations. The daily range is greatest in the lower altitudes, decreasing from about 50° F. in the pinon-juniper to about 20° F. in the Engelmann spruce. From the Engelmann spruce type to timber line there is a noticeable increase in range due to the exposed situation of the timber line station.

2. Precipitation increases rapidly with altitude up to the Douglas fir type. From the Douglas fir to the Engelmann spruce type it remains almost stationary, but at timber line there appears to be a substantial increase.

3. Wind movement is normally greatest in the higher altitudes, but this relation is not always indicated for the reason that some of the stations are located in the forest while others are in the open. The highest records are obtained at timber line, and the lowest in the spruce forest.

4. Evaporation records show no constant relation to altitude, because wind movement and exposure to sunshine, two of the strongest factors influencing evaporation, vary at the different stations according to density of cover. The highest records obtained are in the pinon-juniper type, and the lowest in the Engelmann spruce type.

5. On the basis of origin there are several general soil types in this region. Those in the pinon-juniper type are derived from sandstone, limestone and basalt. In the yellow pine type local areas of limestone and sandstone occur near the lower limits, but basaltic soils predominate over the type as a whole. Above the yellow pine type all the soils are derived from volcanic rocks.

Probably the most important soil character to be dealt with in this region is the capacity for absorbing and delivering moisture as determined by permeability, water holding capacity, and wilting coefficient. From this standpoint the heavy clay soils common through the yellow pine type present the least favorable conditions for growth, particularly with respect to natural reproduction. Although these soils have a high water holding capacity, they also have a high wilting coefficient, and unless mixed with a large proportion of stone and gravel they are exceedingly impervious. High precipitating, low evaporation, and a high degree of permeability tend to create a large moisture supply in the Douglas fir and Engelmann spruce and alpine types.

Soil temperature is of importance mainly through its indirect effects. When the soil temperature falls to 32° F. or even a few degrees above 32°, the soil moisture ceases to be available to plant roots. If this condition persists continuously over long periods during which transpiration is favored by sunshine and wind the result may be fatal to a tree which is unable to endure extreme desiccation.

6. The data obtained indicate that the upper limits of all the forest types are determined primarily by low temperature as related to photosynthesis, and that the lower limits are determined primarily by deficient moisture supply. Low soil temperature, by rendering the soil moisture unavailable to the roots, may under certain conditions as at timber line become the upper control; but, at least as far as reproduction is concerned, this is not believed to be a prevalent factor in this region, for the reason that in the high altitudes, the only places where long periods of continuously low soil temperature occur, transpiration in seedlings is reduced to a negligible quantity by a deep snow cover. Deficient moisture rather than high temperature is regarded as the lower control because observations supported by experimental data on nearly all of the species in this region indicate that when adequately supplied with moisture they are capable of enduring high temperature far in excess of those which occur at the lower limits of their natural range.

FORECASTING HURRICANES

ONE of the most troublesome features of the hurricane, from the meteorologist's point of view, is that the main part of its course lies over water, and, since ships make every effort to escape the storm, the forecaster is left in utter darkness as to the exact location of the disturbance and its direction of movement. For this reason, it is necessary to utilize whatever observational data can be obtained along the coast. Dr. Cline, of the New Orleans office of the Weather Bureau, has recently stated his belief that the tides are a reliable criterion of the direction of motion of the hurricane while a considerable distance at sea.

Dr. Cline, after a brief mention of the wave-producing powers of winds, takes up all the hurricanes which occurred between 1900 and 1919. In their chronological order, he points out the relations existing between the tides at various Gulf stations, and the position of the hurricanes in the Gulf. He is enabled by these studies to show the portion of the storm in which the greatest wave-producing winds occur.

Dr. Cline has given a diagram of the type of waves and swells which emanate from a hurricane, and he finds that the greatest waves are produced in the rear right-hand quadrant of the storm and travel forward through the storm and make themselves felt far in front and mostly to the right side of the line of advance at the time the wave left the storm. These waves travel in the direction of the storm's motion. Waves of lesser amplitude are sent out to the right and left of the center of advance of the storm in the front half; still smaller, weaker waves are sent out to right and left in the rest of the storm; and, finally, the weakest waves of all are sent out in the rear.

It appears that as these waves begin to reach the coast there is a piling up of water, which is, of course, in excess of the normal predicted tide. By carefully noting and comparing the high water at various stations it is possible, Dr. Cline believes, to detect changes in direction of movement of the disturbance. As an example of this, and also of the fact that the rise of water preceded any change in the barometer, he cites the case of the storm of September 11-14, 1919, in which the "barometer at Burrwood, New Orleans, Galveston and Corpus Christi was either stationary or falling only a few hundredths of an inch, the water, first at Burrwood, later at Galveston and then at Aransas Pass was rising in feet, telling the story of the movement and of the change in the course of the storm as plainly as could be told."

By this method it is possible to tell whether the storm is shifting its course to right or left by the shifting of the point of greatest rise to right or left. The regular tides are not obscured by these storm tides except perhaps in the last twelve hours before the storm strikes, when there are other features of prognostic value which can be relied upon. The highest water occurs a few miles to the right and at about the time of passage of the center and high water is observed from 100 to 200 miles to the right of the storm, while to the left it is hardly observed at all.

The apparent simplicity of this method of forecasting hurricanes must not be overestimated, however. The hurricane is a capricious disturbance and difficulties may be introduced by its unusual conduct either with respect to its rate of movement or point of recurving. An example of this may be made in the hurricane of September 21-22, 1920. This storm, as indicated by the tides after it entered the Gulf, was moving in the direction of the coast between Corpus Christi and Galveston; but it recurved and with unexpected speed swept northward and inland near Morgan City, La.—Abstract from *Science*, December 31, 1920. Article by C. LeRoy Meisinger.

THE TOXICITY OF SALTS TO FISHES

It is well known that bodies of water become uninhabitable for some of the most valuable food fishes, both through natural causes and contamination. Certain investigations indicate that the conditions and the reactions of the water have more to do in determining the habitability of a body of water for food fishes than other factors, such as the availability of food. Shelford has shown that fish do not always occur where their natural food is most abundant. It has been shown by reaction experiments that fishes generally avoid injurious substances which they encounter in nature. But the avoidance of injurious substances which do not generally occur under natural conditions is not so marked. In fact, fishes may react positively to such substances.

Leibig's law of minimum, as it is generally stated, "The yield of any crop always depends on the nutritive constituent which is present in minimum amount," can be applied in a modified form to the habitability of a body of water by fishes; *i.e.*, the presence of any one substance may render a body of water uninhabitable for a species of fish. But as Livingston has stated, "This principle is still quite incomplete logically and its statement will assuredly become more complex as our science advances." The deleterious effect of a substance may depend on the stage of the life-history of the fish, whether it be the developing egg, a young and rapidly growing fry, or an adult. In any of the free moving stages of the life history the effect of the injurious substances may become more sensitive or less sensitive and thus react more definitely or less definitely to any environmental factor. At all stages of the life-history of a fish a deleterious substance may become injurious more rapidly under one set of conditions than under another; or, under still others, it may not be injurious. One of the environmental factors which determine the rapidity with which a substance becomes fatal is temperature. The temperature effect, however, may not be so simple, since the content of the water itself is determined by the season of the year, temperature, light, etc., and the fishes themselves probably have seasonal variations.

All these facts have an important bearing on the problem dealing with the fish in relation to its environment.—Abstract from article by E. B. Powers in *Ecology* for April, 1920.

ANATOMICAL REDUCTION IN SOME ALPINE PLANTS

Mr. C. C. Forsaith contributes to *Ecology* for April, 1920, an interesting article on Anatomical Reduction in Some Alpine Plants.

The material described by the author was collected during the latter part of July, 1919, on the Presidential Range in New Hampshire. The species chosen for investigation represent the well-known gnarled and twisted "Krummholz" growth characteristic of alpine regions. The specimens were secured from sheltered pockets on the lower slopes of the cones and near the upper limits of shrubs.

Examining the several environmental factors, Mr. Forsaith says that the high acidity and sterility of the soil in which these species grow has been caused in large part by water which, leaching through from the upper slopes, has carried away the constituents normally present in other soils. In addition to such a diminution of the organic content, the water has washed away much of the inorganic substance so that plants are often forced to live practically upon bare rock, or at best upon a thin stratum of coarse earth. Besides a poverty-stricken soil, the plants must contend with the rigors of an arctic climate.

The relative humidity as registered at the base and summit of the mountains shows little variation, and doubtless has little influence in the development of a specialized flora.

The especially high wind velocities are very important environmental factors. In addition to being intense, the wind comes in gusts, which causes abrupt changes in pressure as well as snapping and twisting strains in the plants.

The final factor in the environmental series is rainfall. Although the yearly aggregate is equal to that of any other locality east of the Mississippi and far above the average of 44 inches, very little of the water is available for the use owing to a rapid run off from the steep rocky slopes.

Examining three species, *Betula alba*, *Alnus Crispa* and *Rhododendron lapponicum*, Mr. Forsaith finds that all three have shown a marked similarity in their development, and consequently that one seems justified in assuming that a uniformity of cause has produced like results. All have suffered reduction in the storage tissue, and in addition all seem to have followed the usual trend of evolution in their respective genera. Furthermore, they appear to have progressed farther in many cases than have their low-land kin, and may therefore be regarded as high types.

Inquiring more closely into the environmental forces which doubtless have been responsible for progression in alpine plants, the author finds that the chief method of control, exerted by temperature, seems to have been as a gage for metabolism, which in its turn has determined the pace of progression. Physiological studies relative to the effects of heat upon growth have shown that there is a very definite affiliation with the rate of production, and that the rapidity of assimilation of carbon dioxide is practically doubled for every 10° C. within certain limits. It is no small wonder, therefore, that an alpine habitat has been the cause of alterations in structure which are generally manifest in the conservation system as shown in the diminution of the ray mechanism in the alpine birch, alder and lapland rosebay.

That this process of curtailment in the storage tissue is indicative of progress is shown by similar phenomena in closely allied species among the catkin bearing plants. Such an assumption is further strengthened by the retention of broader rays about the conservative leaf trace and traumatic tissue in *Betula cordifolia*, and by appearance of compound rays in the region of the follar strands in alpine rhododendron even after they have disappeared from other portions of the axis.

In contrast to such simplification in plants from high, bleak mountains, *Alnus nitida* shows that a species growing under more beneficial surroundings has had a marked tendency to increase its storage organization in order to conserve the excess of food brought down from the leaves. The much elaborated aggregate rays in the Himalayan alder shows that such has been the case, and that semi-tropical surroundings have been instrumental in augmenting the parenchymatous areas.

In contrast to this type of development, a cold, hostile climate in alpine regions has through a reduction of the nutrient materials available for growth forced the plants indigenous to high altitudes to undergo radical changes in the fight for existence. In the light of genetic sequence, therefore, such an evolution may be considered as progressive, and on this account species growing in such regions may be classed as high types among their close kindred living in the more sheltered valleys.

Research Work of the United States Bureau of Standards

Notes Specially Prepared for the SCIENTIFIC AMERICAN MONTHLY

NATIONAL SAFETY CODE FOR THE PROTECTION OF THE HEADS AND EYES OF INDUSTRIAL WORKERS

THREE years ago the Bureau coöperated with the War and Navy Departments in preparing a set of safety standards to be applied in government establishments. Among these standards was one for head and eye protection and this has formed the basis of the code mentioned above. The rules originally laid down have been further developed by study and experimental work at the Bureau and conferences have been held with many individuals and firms who have had experience in protection of this sort.

Preliminary drafts have been issued and comments received from all sections of the country, so that the present Code may truthfully be said to incorporate the latest and best ideas on this important question. No attempt has been made to specify any particular style or strength of safety goggles or other appliances, but rather to indicate and classify the character of the hazards which exist in the different industries, leaving each employer or officer in charge of safety work to assign to these different groups his own particular industrial operation. The various processes have been divided into nine groups according to the degree of hazard, or because the peculiarities of the operation require a protecting device having certain distinct properties. These groups cover many different operations, from the handling of molten metal to exposure to harmful radiations.

THE THIRTEENTH ANNUAL CONFERENCE ON WEIGHTS AND MEASURES

EACH year there is held at the Bureau of Standards a conference of weights and measures officials from every section of the country. Many representatives of manufacturers and other persons interested in the formulation and enforcement of weights and measures laws are also present, so that the conference may be said to truly represent all those concerned with the use and enforcement of standards of weight and measure in the United States.

The thirteenth conference which was held last spring is described in Miscellaneous Publication No. 43 of the Bureau of Standards. The publication is a verbatim report of the proceedings and contains addresses by the Secretary of Commerce, the President of the Conference, and reports of delegates representing the various states, concerning conditions within their jurisdictions. The subjects treated include: Gasoline pumps from the standpoint of safety; the employment of net weight in sales; the standardization of containers for foodstuffs; weights and measures education in the schools; machine measurements for drygoods, and the resolutions adopted by the Conference.

The report of the Committee on Specializations and Tolerances which was devoted to the subject of liquid measuring devices is also given, as well as the discussion concerning the various provisions. The appendix gives the complete specifications and tolerances for liquid measuring apparatus.

THE EFFECT OF REPEATED REVERSALS OF STRESSES ON DOUBLE REINFORCED CONCRETE BEAMS

WHEN the United States was called upon to greatly increase the size of its merchant marine, owing to the war emergency, it became necessary to construct vessels in the shortest possible time and from various classes of materials. It was considered desirable to attempt to build some of these vessels from reinforced concrete and the way in which this work was carried out is now familiar to most people through the articles which have appeared in the technical press.

The extensive investigational work which necessarily preceded the construction of such vessels has not been so fully described. In order to build a concrete ocean-going vessel, it was necessary to subject the concrete to much higher stresses than are considered allowable in building operations; otherwise the walls of the vessel would have been so thick that its carrying capacity would have been greatly reduced and its dead weight increased to a prohibitive figure.

In connection with the production of concrete ships, the Bureau was called upon by the Emergency Fleet Corporation to make a complete investigation of the effect of a large number of reversals of stresses in double reinforced concrete beams. The investigation covered a considerable period and the complete results have only recently been published for general circulation, as Technologic Paper No. 182 of the Bureau of Standards.

The paper first of all describes the nature of the tests, which were designed to simulate to some extent the effect produced upon a ship by the action of the waves. These cause an alternate upward and downward deflection of the material of which the vessel is built; this action being known among nautical men as "hogging" or "sagging." The specimens used for the test were concrete beams with reinforcement both in the top and bottom. The beams were 4 x 6 inches in cross section over-all and were tested with a span of 8 feet. The load was applied at two points, each 6 inches from the center of the span. It was applied at the rate of about 17 cycles per minute, each cycle including one upward and one downward application of the load. By means of a system of levers, the dead-weight used for the load was multiplied ten times at the beam. The loading mechanism was driven by an electric motor acting through a walking beam. Four beams were tested to failure and a fifth was loaded alternately through 2,000,000 cycles, after which the test was discontinued, although the beam did not appear to be approaching failure.

In the case of the four beams on which the tests were completed, failure was by tension in the steel and, generally, the beams showing the highest stresses withstood the smallest number of repetitions. However, even the largest number of repetitions was so small that failure in the steel would not have been expected as the observed stresses were very low. Other factors than the intensity of the tensile and compressive stresses evidently had a part in bringing about the early tension failure. All the tension failures in the reinforcing bars

occurred at sections where large cracks extended entirely across the section of the beams. It is possible that in some cases the bending at these cracks was sufficient to make the bending of the bar an important factor in causing failure. This tendency was probably accentuated by the slipping of bars at the ends which occurred with one of the beams and was accompanied by the opening up of wide cracks. The presence of gage holes in the bars apparently had some influence in hastening tension failure, but the nature of this influence was not very distinct. The quality of steel used for most of the reinforcement was poor and this would contribute to bringing about an early failure although it does not alone account for the small number of repetitions of stress which were withstood in these tests.

After 7,000 cycles of load, the slip at the end of the bar in one of the beams was less than 1/1000 of an inch, that is, less than the amount which has been taken as the criterion of safe conditions based on tests of the bond resistance between concrete and steel; yet after 400,000 cycles of load, the amount of slip had increased so much that failure by slipping of the bars seemed imminent. In all probability, had not tension failure intervened after an unexpectedly small number of repetitions of load, bond failure of this specimen would have occurred.

GYPSUM—PROPERTIES, DEFINITIONS AND USES

A RECENT circular of the Bureau of Standards has been issued on this subject and may be summarized as follows:

Gypsum is a soft white rock, usually occurring in beds. Other varieties of the same material are known as gypsite and alabaster. It is of common occurrence throughout the United States. Chemically it is a calcium sulphate combined with water. Anhydrite is a variety which contains no water.

Raw gypsum is used for the manufacture of portland cement and as a fertilizer.

Calcined gypsum is made by heating raw gypsum in a kettle until the first evolution of water has ceased. It contains one-fourth as much water as the raw material. This product is frequently known as plaster of paris and is used either as such or as the basic ingredient for the manufacture of wall plaster, potters' plaster, dental plaster, etc. Large quantities of it are used in the manufacture of portland cement, plate glass, and cold-water paints.

When calcined gypsum is mixed with water, it sets to form a hard mass. The time required for this reaction can be varied at will by the addition of suitable retarders or accelerators.

Neat gypsum plaster is calcined gypsum to which has been added some material (such as hydrated lime) to improve its working quality, and the proper amount of retarder. Gypsum sanded plasters are mixed with sand ready for use. Any of these plasters may or may not be "fibered" with either hair or wood fiber, and a special wood-fibered gypsum plaster is made to be used without sand.

Gypsum plasters have excellent fire-resistive ability. The raw gypsum can be heated until all of the water is given off. The product so formed sets more quickly than calcined gypsum. It is not marketed, but is used at the factory to make such products as gypsum tile, gypsum plaster board, gypsum wall board, etc.

Further heating of the raw gypsum forms a material which sets very slowly. An accelerated variety of this is marketed as Keene's cement.

Gypsum tiles are factory-made building blocks. They come in a great variety of sizes, either plain or reinforced. They are used for building walls and roofs.

Gypsum plaster board consists usually of a sheet of set gypsum plaster between two sheets of unsized paper. It comes in many sizes, usually about 3 feet square by ⅜ inch thick. It is used instead of lath as a backing for plaster.

Gypsum wall board is of about the same construction as gypsum plaster board, but the paper is sized so as to furnish the finished surface of the wall. It comes in strips 4 feet wide by any length from 6 to 14 feet, by 5/8 inch thick.

The Bureau is coöperating with the Gypsum Industries Association in research work on this subject, and the Association has established a fellowship at the Bureau.

Recommended specifications for calcined gypsum, neat gypsum plaster, gypsum plaster board, and gypsum wall board are given in full, for which the original paper should be consulted.

DETERMINATION OF THE STANDARD FOR "WHITE LIGHT"

THE definition of "white light" naturally constitutes a very important part of the scientific foundation of colorimetry. If we consider incandescent light sources generally (including oil and gas flames; carbon and metallic filament electric lamps) we find that the light from sources at comparatively low temperatures evokes reddish or yellowish colors. As the temperature of the source increases, the color becomes paler and paler yellow and, at higher temperatures, approximates to "white." However, all artificial incandescent sources are decidedly yellow in comparison with sunlight, since it is not possible to operate an artificial source at a sufficiently high temperature to color-match sunlight. We are led to anticipate, however, that a source at a sufficiently high temperature would color-match sunlight, and further that sources of still higher temperatures would appear blue relative to the sun. The question arises as a matter of physiological optics at what temperature would a source appear under standard conditions of observation neither blue nor yellow but white? The further question then arises relative to this standard, is the sun blue, yellow or white? Recent experiments made at the Bureau answer these questions in so far as four observers are concerned. They are the first accurate experiments of this nature ever performed. The answers are:

(1) Theoretical. The temperature which a hypothetical source would have in order that its light might evoke the sensation white (the hueless sensation of brilliance recognized as neither bluish nor yellowish) would be about 5,200 degrees absolute Centigrade.

(2) Practical. The light of the average noon sun at Washington evokes a sensation closely approximating white.

These experiments and their results were describel at a joint meeting of the American Physical Society and the Optics Society of America in Chicago, December 29, 1920. It is expected that they will be described in detail in a forthcoming publication of the Bureau of Standards.

INVESTIGATIONS IN ELECTRONICS

Two general types of inelastic impact between an electron and an atom may occur. The first of these results in an orbital shift of the electrons bound in the atom, and the second in the complete removal of an electron or ionization of the atom. The respective potential differences through which an electron must fall to acquire sufficient velocity for these two types of collision to occur are known as the resonance and ionization potentials for the particular metal in question. The determination of these constants has been continued. Work of this character is of theoretical interest from the standpoint of pure physics, and of practical interest in that it furnishes further evidence toward an explanation of the phenomena of ionization and related problems which arise in the design of vacuum tubes for wireless telephony and telegraphy, rectifiers, etc.

Two scientific papers entitled "Ionization and Resonance Potentials of Some Non-metallic Elements," Scientific Paper No. 400, and "Resonance Potentials and Low Voltage Arcs for Metals of the Second Group of the Periodic Table," Scientific Paper No. 403, respectively, have been published. The first of these gives data for phosphorus, while the second gives data for zinc, cadmium, mercury, magnesium, and calcium, with predicted data for strontium and barium.

Research Work of the U. S. Bureau of Forestry

Notes from the Forest Products Laboratory at Madison, Wisconsin

LUMBER USED IN THE MOTOR VEHICLE INDUSTRY

THE rapid increase in the proportion of closed cars manufactured is an outstanding feature of the automobile industry. An official of a large company recently expressed his belief that in five years one-half of their output would be closed cars. Already one out of every eight pleasure cars of a well-known make is a sedan or coupe. This means a large consumption of lumber, as the closed car takes from two to three times as much lumber as an open car, and a better grade of lumber is required to insure rigidity and freedom from warping in the closed body. An engineer of the U. S. Forest Products Laboratory, Madison, Wisconsin, recently visited a number of manufacturing plants to determine what woods are now being used in the automobile industry, to what extent substitution of one species for another is taking place, and what troubles manufacturers are having with wood. He found that maple leads for use in the construction of bodies, elm is next, and ash is third. More 2- and 3-inch stock is used than thinner materials. The following comments are to be noted in connection with the use of various woods:

Maple.—At most of the plants visited by the representative of the Forest Products Laboratory, maple was used for body sills (in one plant practically the entire framework and even the floor boards of the car were made of maple), although ash is used for sills at some of the plants. Maple is cheaper, and is generally more uniform in quality than ash, and warps less than elm. In one plant birch was suggested as a substitute for maple, but it is more expensive. Maple is said to hold screws less rigidly than elm because it is less fibrous and after use the screw hole becomes enlarged and smooth, permitting the screw to come out easily. One company preferred birch to maple in sedans because they claimed it would take and hold varnish better, especially on rounded corners. Maple was also said to split more easily than elm, making it difficult to saw curves with economy.

Elm.—Elm seems to be the principal wood used for the framework of open bodies. Soft elm is used except for the trim rails, which are of rock elm or a good grade second-growth soft elm bent to proper shape. Soft elm works easily, holds screws well, and does not split easily. Stock up to 4 inches in thickness is used.

Ash.—Ash was formerly used almost exclusively in automobile work, but due to its greatly increased cost it is now used only on high priced cars, and on cars with closed bodies which command a relatively high price. Ash is preferable for use in framework of closed cars because it holds its shape well. At one plant trouble was experienced with maple as compared with ash and this made the cost of maple equivalent to that of ash. A tough sill is required to reinforce the steel frame. That the wood actually reinforces the steel frame is shown by the fact that breaks in the frame usually occur at the front end of the wood sills, that is, near the dash.

Birch.—The use of birch is probably increasing in automobile manufacture. Some manufacturers report its use in sills and frames. It is preferred to maple on exposed painted parts because it is said to hold the paint better. It is said to be as good as maple as far as mechanical properties are concerned and better in seasoning properties, but usually it is slightly more expensive.

Hickory.—This species is used for spokes and rims only.

Gum.—An appreciable quantity of red gum is used for various parts, such as foot risers, foot boards, strainer slats, and floor boards. It has been used for frames and steering wheels.

Other Species.—Among the other species used for minor parts of automobiles are the following: Wormy oak is used for running boards, floor boards, and foot boards and foot risers. For top bows second-growth, at least so-called second-growth oak is used principally, although some elm is now used. Sycamore is used to some extent for posts and pillars. Yellow pine is used for floor boards and running boards. Douglas fir has been used for the same purpose as yellow pine. Basswood, cottonwood, and yellow poplar are used for minor parts.

Table 1 shows the kinds of wood used in the different parts of an automobile, based on a study of these companies which made bodies for a number of automobile manufacturers.

Table 1.—*Kinds of Wood Used in Open Cars*

Sills, longitudinal and cross	Ash, hard maple, and occasionally elm, red gum, magnolia and soft maple
Floor boards	Sound and wormy oak, hard and soft maple, red gum, beech, wormy chestnut, elm
Seat risers, or "heel boards"	Hard and soft maple, red gum, yellow pine
Seat boards, or seat frame	Hard and soft maple, red gum, and numerous other species
Seat lids	Maple, gum, elm, and numerous other species and plywood
Pillars and posts	Hard and soft maple, ash, elm, sycamore, and red gum
Seat rails (arms and back)	Ash, elm, and maple
Strainer slats, or "spring slats"	Maple, ash, and gum
Doors	Hard and soft maple, ash, and elm
Trim rails	Rock elm
Running boards	Wormy oak, yellow pine, maple, Douglas fir
Steering wheels	Walnut, maple, red gum
Spokes	Hickory
Rims ("felloes")	Hickory
Top bows	Oak
Dash	Cottonwood and maple

It is estimated by the Forest Products Laboratory at Madison, Wisconsin, based on studies made by a member of its staff in recent visits to a number of automobile manufacturing plants, that the total amount of wood used in the construction of automobiles and motor trucks in the United States amounted to 384,751,000 feet b.m. in the year 1919. The total consumption of wood used in the industry is roughly estimated in Table 2.

Table 2.—*Amount of Lumber Used Annually in the Manufacture and Shipment of Passenger Cars and Motor Trucks Based on 1919 Production of Cars*

Total output of passenger cars	1,660,000	
Average number of board feet of lumber used per car	160	
Total lumber used in passenger cars		265,600,000 bd. ft.
Total output of motor trucks	316,500	
Average number of board feet of lumber used per truck, including body	200	
Total lumber used in motor trucks		63,300,000 bd. ft.
Total number of passenger cars exported	66,400	
Average number of board feet of lumber used in export crating of passenger cars	660	
Total lumber used in export crating of passenger cars		43,824,000 bd. ft.
Total number of trucks exported	15,825	
Average number of board feet of lumber used in export crating of trucks	760	
Total lumber used in export crating of motor trucks		12,027,000 bd. ft
Grand total		384,751,000 bd. ft.

The amount of lumber used in each car varies from 75 feet b.m. for a small open car to 200 feet b.m. for a medium-priced touring car. An average given by a large body manufacturing corporation is 140 to 150 feet b.m. for open cars for

each body. A small sedan requires 225 feet b.m. and a large sedan, not including running boards, uses about 310 feet b.m. One company stated that the average waste was about 30 per cent, including drying losses, cutting, and minimum jointer waste, although others place the waste as high as 40 per cent. In automobile work firsts and seconds are used nearly exclusively. One company used 75 per cent first and seconds and 25 per cent No. 1 common. A large body company used 40 to 50 per cent first and seconds, and the rest No. 1 common of maple, elm, and oak. Another company making high-priced cars will take only 20 per cent of No. 1 common.

MANUFACTURE OF ETHYL ALCOHOL FROM WOOD WASTE

Sawdust and shavings are generally waste products in the manufacture of lumber. Where other waste in the form of slabs and edgings from large logs is available, the manufacture of pulp for paper is a desirable method of utilizing waste material; buf, if the product is largely sawdust and shavings, the manufacture of ethyl alcohol is probably more economical. There are two general processes for converting wood into fermentable sugar: those using a concentrated acid, and those using a dilute acid under pressure.

The first method depends upon a complete solution of the cellulose in a highly concentrated acid. The resulting products are then hydrolyzed to sugars by boiling with a large volume of water. By this process yields of sugar corresponding to fifty per cent of the dry weight of the wood are obtainable; but the disadvantages connected with the process more than offset the advantage of a high sugar production. The disadvantages are first, the lack of a satisfactory method for the recovery of the acid used, a necessary procedure in view of the large quantity of acid required; and second, the difficulty of constructing apparatus capable of withstanding the corrosive action of the hydrolyzing agent.

The second process is commercially feasible and has been used successfully in this country by two plants for the last few years. It is, however, limited at present to those mills cutting soft woods, since experiments have shown that the yields are about one-third greater from coniferous wood than from the broad-leaved varieties.

This process consists of digesting sawdust, or a mixture of sawdust and shredded mill waste, with dilute sulphuric acid for 15 or 20 minutes at a steam pressure of 115 to 120 pounds. This operation is carried out in a rotating digester lined with acid-resisting brick and results in a conversion of 20 to 25 per cent of the dry weight of the wood into sugars. about 75 per cent of which are fermentable. The sugars thus produced are then removed from the digested material by extracting with water in a diffusion battery similar to those used in the beat sugar industry. The sulphuric acid is eliminated from the sugar solution by treating it with lime or calcium carbonate and allowing the sludge to settle. The settling requires fifteen to twenty hours. The clear solution is then drained off, cooled to the proper temperature, and fermented in much the same way as is cane sugar molasses. The alcohol produced is removed by distillation and rectified in a manner similar to that employed in the manufacture of industrial alcohol from grain, molasses or other materials.

The essential parts of a plant necessary to produce ethyl alcohol from wood, considered in order of their use, are the following: Dust house for the storage of an adequate supply of sawdust; hogs, shredders and screens; sawdust storage above digesters; acid and lime storage and mixing houses; digesters; diffusion battery; neutralizing and settling tanks; coolers; fermenting tubs and yeast equipment; beer still; rectifying still; and bonded warehouse.

For best economy this plant must be operated continuously, and it should therefore have at least a 15-day supply of wood on hand; and where logging operations are such as to require frequent shut downs, the alcohol plant should have sufficient material in storage to tide over. The steam consumption in the plant will be distributed about as follows: Pump, 20 per cent; digester, 30 per cent; hogs and shredders, 20 per cent; general power, 15 per cent; distillation and rectification, about 15 per cent; including exhaust steam.

While it is unfortunate that several early failures occurred in plants using this process, these failures were due to (1) difficulties encountered during the general development of the process because of the lack of experience in the commercial application of such a process; (2) promotional difficulties; (3) lack of technical experts in this field who have the necessary chemical, engineering, and bacteriological skill to develop the operation; (4) difficulties have also been encountered by the erection of a plant at a point where insufficient quantities of wood were available, a condition which naturally interferes with the continuous operation of such a plant.

The fact that two plants have operated successfully in this country for the past few years indicates that the process is commercially feasible. Investigations at the Forest Products Laboratory indicate that after allowing the necessary manufacturing losses, a yield of 20 gallons of 95 per cent alcohol per ton of dry wood is obtainable from the coniferous wood.

An alcohol plant, to be successful, should have a minimum daily production of 1,500 gallons of 95 per cent alcohol. This would require 75 tons of dry wood, or its equivalent, in air-dry or green condition, and comparatively free from bark. A smaller plant than this would increase the distillation and rectification cost to a questionable figure because continued operation would no longer be possible in standard apparatus. Such a plant would cost approximately $250,000 to $300,000 under normal conditions. When conditions permit, however, a larger plant is desirable. The distribution of cost in a plant using 225 cords (180 tons dry wood) a day and operating 24 hours a day of three 8-hour shifts in all departments excepting the digester, lime and acid house, when two 9-hour shifts will suffice, will be approximately as follows:

Item	Cost per gallon of Ethyl Alcohol Produced
Interest, depreciation, taxes, and insurance	$0.046
Raw material, wood, sulphuric acid, lime, fermentation materials, and fuel	0.087
Labor	0.060
Executive salaries, and other overhead expenses	0.050
Total	$0.243

The cost of wood is taken at 50 cents per cord. This is a very low cost of manufacture and it would only hold under conditions outlined.

BETTER CRATING

Boxing and crating has been and likely will continue to be a serious question with all exporters, especially automotive exporters. It is generally admitted that the laxity in crating results from ignorance of the conditions that the package will encounter rather than a deliberate intent on the part of the packer to wreck his merchandise en route.

During the war the munition and other shippers are reported to have accomplished a very good job in the packing. This was done by specifications, based on Laboratory investigations, provided by the Government for the particular job.

Now the laboratory is quite willing to provide a similar service for any packer who may be willing to come to Madison and study the situation. This is arranged in the way of special classes consisting of 12 men each. An intensive six-day course is provided. Classes will be organized on January 10, March 7 and May 2, 1921. A coöperative fee of $100 is required, in addition to each student's paying his personal expenses. The fee goes toward the support of the laboratory.

Application should be made by the firm that is sending the student, as this is not a plan to equip a man to get a job, but a plan to accomplish a definite service to trade generally.—From editorial in *Automotive Industries*, Dec. 16, 1920.

Progress in the Field of Applied Chemistry

Notes Culled from Current Technical Literature

By H. E. Howe, Member of American Chemical Society

FOOD INVESTIGATIONS

THE report of the Food Investigation Board of the Department of Scientific and Industrial Research of Great Britain for 1919 is now available and will be found of unusual interest. There has been a prolonged investigation of the effect of cold storage upon that accessory food factor known as fat soluble (a vitamine), and it is reported that cold preserves this necessary substance completely. This result is of considerable scientific importance as it will make possible the study of the influence upon the quantity of vitamine present in butter or milk, for example, of the diet of the animal and of the season of the year. There has been an extended study of the effect of cold storage upon the food factors of fruits and directly or indirectly on the preservation of food by cold. The report states that so far as is now known there is no agent which preserves the nutritive properties of foods so completely as does cold, at the same time maintaining the food in a condition fit for human consumption. The meat committee has completed experiments upon the freezing of beef and it is remarkable that whereas mutton can be frozen without damage, beef cannot. This is true so far as present methods as practiced by industries are concerned but the new experiments prove that under proper precautions beef can be frozen in a satisfactory manner. Ordinarily freezing alters the muscle substances so that upon thawing a fluid rich in nutritive material exudes.

With respect to the diet of animals experiments indicate that dried blood added in small amounts to the diet of pigs produces a remarkable increase in the rate of fattening.

Attention has also been given to methods of drying fruits and of the respiratory metabolism of fruit at low temperatures. The oxidizing enzymes responsible for the discoloration of certain fruits on injury have also been included in the survey. The chemistry of the ripening processes in fruit with special reference to the changes in the pectin have been investigated and the limits of temperature within which the molds which commonly infest it in storage will grow have been determined.

The reports include certain details with reference to the experiments and results and can be obtained for six shillings from H. M. Stationery Office, Imperial House, Kingsway, London, W. C. 2.

AMERICAN POTASH INDUSTRY

American Chemical Society News Bulletin reports an address by Dr. J. E. Teeple on the present status of the American potash industry. Quoting Dr. Teeple, "In 1918, the banner year, 128 different plants operated, giving a total production of over 54,000 tons of potassium oxide. In 1919, with the fall of the price of potash, this production dropped to about 30,000 tons. Out of the 128 plants reported as producing in 1918, only 43 were reported as producing in 1920. With the price of potash in 1921 still lower than it was in 1920, we may expect a still greater falling off in the number of producing plants, and possibly in the total output.

"We have not reached a point where our cost of production is as low as 75 cents per unit of potassium oxide, which was about the minimum selling price of German potash before the war, but we are beginning to see where we may get within shooting distance of it. It will probably take two or three years yet to work out this problem to a finish, where we are producing potash at Searles Lake in large quantities as cheaply as it can be produced there. When this point is reached I do not think we need seriously fear German or any other com-

"The two largest items of cost we have at the present moment in production are fuel and freight, and if we can get any kind of ultimate coöperation from the oil producers and from the railroads we will be able to supply a large part of this country's need of potash without any protection. Do we need protection until this work is finished? It is probable that we do. Germany's need of money and goods is a most serious need. There will be a great temptation for her to convert some of her supplies of potash into immediate cash. Probably no potash plant in America could sell this product today at one dollar per unit and cover its cost of production.

"Our experiences hold that where production ceases there is little incentive to keep expending money on research and development work. Prices of potash during the past year have averaged close to $150 per ton of potassium chloride. On the basis of our average consumption, this represents close to $60,000,000. Before the war this would have represented around $20,000,000. The size of either figure makes it well worth while to encourage the growth of such an industry in this country, since apparently it has every prospect of being able to live alone and do its own fighting, once its development period is over."

REORGANIZATION OF SCIENCE IN SECONDARY SCHOOLS

THIS is the title of Bulletin, 1920, No. 26, Department of the Interior, Bureau of Education, and affords some interesting observations on the necessity for reorganization and the advantages to be gained from the pursuit of science in our secondary schools. The principal aims in teaching chemistry in the high schools are given as follows:

"1. To give an understanding of the significance and importance of chemistry in our national life. The services of chemistry to industry, to medicine, to home life, to agriculture, and to the welfare of the nation, should be understood in an elementary way.

"2. To develop those specific interests, habits, and abilities to which all science study should contribute.

"The powers of observation, discrimination, interpretation, and deduction are constantly called for in chemistry and are so used in this subject as to require a high type of abstract thinking. The principles and generalizations of chemistry are often difficult. For this reason chemistry should occur in the third or fourth year of the high school.

"3. To build upon the earlier science courses, and knit together previous science work by supplying knowledge fundamental to all science. Coming after at least a year of general science, and usually also a year of biological science, the work in chemistry should further use these sciences. It should furnish a new viewpoint for the organization of science materials, and develop wider and more satisfactory unifying and controlling principles. By this means the desirable element of continuity in the science course will be secured.

"4. To give information of definite service to home and daily life. This aim has been the chief influence in reorganizing high-school chemistry courses, and will undoubtedly produce further changes. The criterion of usefulness, as a basis for the selection of subject matter, should not be limited to the immediately useful or practical in a narrow sense, but should be so interpreted as to include all topics which make for a better understanding of, and a keener insight into, the conditions, institutions, and demands of modern life.

"5. To help pupils to discover whether they have aptitudes for further work in pure or applied science, and to in-

duce pupils having such aptitudes to enter the university or technical school, there to continue their science studies."

Subjects toward which some of the pupils should be directed include the atmosphere as a sample introductory topic, purification of water, a study of lime stone, lime and allied products, simple inorganic preparations having to do with materials of every day acquaintance, and introductory courses in household or domestic chemistry, in chemistry for nursing, for electro-platers, for pharmacy, and in technical curricula special courses for those who may become workmen and foremen in the chemical industries. This is important since in many centers manufacturers permit their employees to study in technical high schools one hour a week in order to increase their productivity and efficiency.

ILLUMINATING AND HEATING GAS FROM WOOD

Chemical and Metallurgical Engineer, January 19, gives the following note on this subject:

"The industry of manufacturing illuminating and heating gas from wood distillation has made rapid progress in Switzerland during the last few years. The disadvantages of wood gas (presence of great quantities of acetic acid, which is harmful to the life of the pipings, and of carbon dioxide) have been greatly reduced by the use of an improvement in wood distillation which consists in passing the gas through incandescent charcoal. The consumption of charcoal is from 1 to 3 kg. per 100 kg. of wood or 3 to 6 kg. per 100 cu. m. of gas. Tests have shown that by this improvement the following results are obtained as compared with those for a simple distillation of the wood:

"The amount of gas produced from a given quantity of wood is nearly doubled.

"The carbon dioxide content is reduced 25 per cent.

"The calorific value of the gas is reduced 22 per cent.

"The heavy hydrocarbon content is reduced about 66 per cent.

"The methane content is reduced 50 per cent.

"The hydrogen content is increased 80 per cent.

"The tar content is decreased 50 per cent.

"The acetic acid content is reduced to a practically negligible quantity. The apparatus and pipings are not deteriorated by these small quantities of acetic acid.

"The gas produced is much lighter.

"The water content of the tar is greatly reduced, thus improving its selling price."

GEOPHYSICAL CHEMICAL PROBLEMS

In the Proceedings of the National Academy of Sciences, Vol. 6, No. 10, much space is devoted to a discussion of research problems in geophysics and in it is included an interesting section on the problems of geophysical chemistry by Dr. R. B. Sosman.

Dr. Sosman points out that 98 per cent by weight of the outer ten miles of the lithosphere is made up of the common oxides and that all the other elements and compounds are known to chemistry and included in the remaining two per cent. These abundant oxides are gives as follows:

SiO_2 About 60 per cent by weight
Al_2O_3 About 15 per cent by weight
FeO / Fe_2O_3 About 6 per cent by weight
CaO About 4.9 per cent by weight
MgO About 3.7 per cent by weight
Na_2O About 3.3 per cent by weight
K_2O About 3.0 per cent by weight
H_2O About 2.0 per cent by weight
CO_2 About 0.7 per cent by weight

The study of these oxides and their combinations is essential to the progress of petrology and such research must proceed from the simple individual oxide to two and three component systems to still more complex bodies. The study of the systems may be divided into (1) investigations of the anhydrous oxides of silicates in the first eight oxides of the list quoted, and (2) investigations including hydrous silicates. Researches are called for not only on the chemical substances of the earth's surface but also upon the aggregates which include the igneous rocks, the pyroclastic and sedimentary rocks, the oceans and other bodies of water, and the atmosphere.

GLASS COLORS

SCHNURPFEIL's Review for Glass Works, 4, 685 (1920), gives the following table relative to the normal color for the ordinary coloring oxides in the kinds of glass indicated and this note is from an abstract appearing in the *Journal of American Ceramics:*

Metal oxide	Lead glass	Potash glass	Soda glass
Silver oxide	....	Yellow or orange	Yellow or orange
Chrome oxide	Greenish red	Greenish yellow	Grass green
Cobalt oxide	Pure blue	Blue	Bluish violet
Copper oxide (red oxide)	Blood red	Purple	Purple (yellowish)
Copper oxide	Green	Sky blue	Sky blue (greenish)
Ferrous oxide	Greenish yellow	Bluish green	Bluish green
Iron oxide	Greenish yellow	Bottle green	Bottle green
Manganese oxide	Amethyst	Bluish violet	Reddish violet
Nickel oxide	Bluish violet	Amethyst	Yellowish violet
Purple precipitate of cassius (gold)	Red or rose	Red or rose	Reddish blue
Uranium oxide	Topaz	Siskin yellow	Greenish yellow
Sulphur. carbon	Black	Golden yellow	Pale yellow
Antimony oxide	Orange (opaque)	....	....
Selenium	....	Pink	Salmon color
Tin oxide	Enamel white	White	White

METHODS OF WATER PURIFICATION

In the January 19th issue of *Chemical and Metallurgical Engineer* there is an excellent article on "A Comparison of Various Methods of Water Purification." The author, W. M. Taylor, divides the purification of water for industrial purposes into five classifications:

"Distillation.

"Removal of suspended matter by filtration.

"Water-softening by filtration through zeolites.

"Water-softening by precipitation.

"Rectification by the use of boiler compound."

There is a general discussion of these various methods of water purification and the general summary is quoted as follows:

"For laundries, textile mills, dyeing plants, manufactories of chemicals, extracts, etc., the quality of whose products is lowered by the presence of calcium or magnesium salts, the zeolite water-softener is preferable if the raw water is such that the zeolite water-softener can handle it and if the presence of sodium salts in the water has no injurious effect.

"If the water for the above industries cannot be handled by a zeolite water-softener, treatment by the precipitation water-softener will usually prove economical and valuable.

"For the manufacture of raw-water ice, the precipitation water softener is the only satisfactory method of treating.

"In larger installations, with an average hard water, which shows no tendency to foaming or priming, for fire-tube boilers, the precipitation water-softener produces the best results.

"In smaller installations, or with a low hardness, or an extremely high hardness, for fire-tube boilers, properly prescribed compounds are preferable.

"For water-tube boilers of any size and for locomotives boiler compounds usually show best results.

"Where high amounts of sodium salts predispose the water to foaming and priming, boiler compounds give best results.

"In cases of electrolytic corrosion, the use of a zinc-bearing boiler compound will frequently correct the trouble.

"From the above conclusion it is apparent that each type of water purification has a fairly well-defined field in which it is unquestionably *best*. The fields, however, where either of two different methods of treatment would give good results

are quite frequently met with, and in these cases individual considerations would decide which of the two methods would be better."

ELECTRO-DEPOSITION OF BRASS

A. L. Ferguson and E. G. Sturdevant are joint authors of a discussion of "The Electro-Deposition of Brass from Cyanide Solutions" which has been summarized in a recent issue of *The Metal Industry.* The summary follows:

"(1) Increase in the ratio of copper to zinc in the solution increases the percentage of copper in the deposit. A solution in which the ratio of copper to zinc is 4.2 gives a deposit of about 65 per cent copper (ratio 1.9).

"(2) Solutions of high metal content are more satisfactory than dilute solutions. A solution containing thirty-five grams of metal per liter, in the above ratio, gives deposits.

"(3) Increase in temperature decreases cathode polarization and consequently increases the percentage of copper in the deposit.

"(4) Increase in current density produces a gradual decrease in the percentage of copper in the deposit. At current densities greater than 0.3 ampere per sq. dm., the deposit becomes granular, non-adherent, and dull.

"(5) Increase in free cyanide does not increase anode efficiency, but does decrease cathode efficiency. Its influence on the percentage of copper in the deposit is variable.

"(6) Slightly acid substances increase the percentage of copper in the deposit. A weak acid may be used in place of any of the acid substances that have been recommended.

"(7) Slightly alkaline substances decrease the percentage of copper in the deposit. The presence of slightly alkaline substances is beneficial in that it improves the appearance of the deposit.

"(8) Neutral substances have no influence on the deportment of the cyanide brass plating solution.

"(9) Brasses which vary in composition from 62.3 to 85.0 per cent of copper dissolve as such anodically. The efficiency of corrosion is about the same as that of copper.

"(10) Decided depolarization of zinc by copper takes place and makes possible the deposition of brass from solutions in which the potentials of the two metals are not equal.

"(11) Electro-deposited brasses which vary in composition from 37.6 to 82.0 per cent copper give nearly the same potentials in a plating solution. These potentials are nearer to that of copper than to that of zinc."

INFLUENCE OF MOISTURE ON THE SHADE OF DYEING

This is a title of discussion by J. Rouffin in *L'Industrie Textile.* Dyers have noted that some coloring matters are modified by heat, the shade usually being reddened. Yellows have become shades of orange and the orange shades tend toward scarlet tones. It has also been observed that some coloring matters are not sensitive to heat while with others the sensitiveness is so extreme that final matching must proceed with great caution. It now appears that heat is not the real cause of these changes but that moisture is the important consideration. The following is quoted:

"It appears reasonable, therefore, to suggest that the variation of the shade may be directly due to the hygrometric state of the material. In attempting to verify this hypothesis, samples of woolen felt dyed with different coloring matters were taken and cut each into three parts. One lot was placed in a desiccator holding a vessel of concentrated sulphuric acid, that is, in a dry atmosphere, where the wool would have the moisture taken from it progressively at the ordinary temperature until completely dry. Another lot was placed in a desiccator holding a vessel of pure water, that is, in an atmosphere saturated with moisture, where the wool would absorb progressively, and without being heated or cooled, the maximum amount of water it is able to carry. The third lot was kept in the air of the room.

"The results have confirmed the hypothesis advanced. In the dry atmosphere the colors became modified in the same manner as takes place by drying them in the dry-room. In the moist atmosphere the colors became modified to the same extent as a wet cold pattern. The experiments were repeated with a large number of the acid and chrome dyestuffs for wool, and in each instance the immediate cause of the alteration of the shade was the hygrometric state of the fiber.

"Heat only intervenes as a moisture-removing agent. That the return to the original shade takes place slowly may be explained by the fact that time is required for dried wool to resume its normal hygrometric state. Many coloring matters are very sensitive to heat, some others are hardly affected at all, while others are most profoundly affected."

COLORS FOR STRAW

Louis G. Hayes, under the title of "The Dyeing of Straw and Hemp," presents interesting information in the January number of the *Color Trade Journal.* Methods of dyeing are discussed as well as colors best suited for different classes of work. The following applies particularly to straw:

"Basic and acid colors are mainly used for this fiber and the following list of colors which are obtainable today will be found sufficient to produce all the seasonable shades.

"The well wetted material should be entered into the lukewarm dyebath in a warm state as in this condition the natural wax is soft and pliable which greatly aids penetration. The basic colors are dyed with the necessary amount of dyestuff and from 3 to 5 per cent of acetic acid (28° Tw.), depending upon the depth of the shade, and boiled from 2 to 3 hours moderately, after which they are removed from the dyebath and washed.

"The acid colors are handled in the same manner with the exception that the dyeing is started without any acid and it is added in small amounts. The dyeing operation may take a longer owing to the slower drawing power of the acid colors.

"Blacks are produced by a mixture of basic colors in the proper proportions, the color generally used being Malachite Green, Methyl Violet and Bismarck Brown.

"The material should be dried at a moderate temperature. It may be noticed that the basic colors have a light bronziness after drying, but, while objectional, this is entirely removed in the sizing of hot shellac that the hats receive after they are sewn and before they are shaped in the hydraulic processes.

Yellow and Orange

Acid	Basic
Azo yellow	Auramine O
Tartrazine	Chrysoidine Y, R
Orange II	Brilliant Phosphine
Croceine Orange	
Metanil Yellow	

Brown

Acid	Basic
Rescorcine Brown R, Y	Bismarck Browns

Pink and Red

Acid	Basic
Fast Red	Cloth Red
Azo Fuchsine	Safranine
Scarlet 2K	Magenta

Croceine Scarlet MOD

In this class also comes Rhodamine which can be used in conjunction with either class of colors.

Blue and Violet

Acid	Basic
Fast Blue R	Methylene Blue
Patent Blue	Fast Indigo Blue
Soluble Blues	Methyl Violet
Induline	Crystal Violet
Nigrosines	Acid Violet 4BN
Acid Black 10B	Victoria Violet

Green

Acid	Basic
Naphthol Green	Brilliant Green, Crystals
Acid Green L	Malachite Green, Crystals."

Progress in the Field of Electricity

Summaries and Excerpts from Current Periodicals

By A. Slobod

THE NEW PORTABLE OSCILLOGRAPH AS APPLIED TO COMMERCIAL WORK

Since the early days of alternating current machines, efforts have been made to get records of actual wave shapes. The rotating contact maker, which momentarily connected a voltmeter to a generator at a controllable point of the wave, was the commonly used device twenty years ago. The result, of course, was rather crude. Nothing in the way of transient phenomena could be investigated by such a device. Duddell is credited with original refinement of the galvanometer to enable it to follow accurately individual waves and transients.

Cumbersome as the early oscillographs were, they permitted the obtaining of hitherto inaccessible data on the electric circuit. The oscillograph has since been greatly developed and its use became so universal that at present no investigation of the general characteristics of an electrical device, by which any alteration of the electromotive force is produced, is complete without the taking of oscillograms.

In the present article Mr. Legg describes a new design of a portable oscillograph and some commercial applications of it. The oscillograph has hitherto been primarily a laboratory instrument, difficult to move and requiring considerable time to set up in a new location. The new oscillograph is readily portable. It is complete in two units. The main case is 14 inches high, 13 inches wide and 25 inches long and contains a housing for an incandescent lamp. Photographic drum and driving head attached to the optical box control switches and ammeter for indicating the field current of the galvanometer. The motor board is separate and carries the induction motor, fitted with stepped grooved pulleys and back gears, the transformer, the lamp control rheostat, the double-throw, double-pole switch for 110- or 220-volt transformer operation and protecting fuses.

The series electromagnet galvanometer is only 7 by 7 by 4.25 inches overall. There are three vibrator elements of a rugged construction. The resistances for the elements, controlled by dials, are wound on thin micarta cards, so as to be nearly non-inductive. One dial gives a range of 0 to 100 ohms, while the other gives a range of 100 to 10,000 ohms. As the element takes about 12 amperes per inch deflection on the photographic drum, it can be seen that the high resistance dial is sufficient to give proper element deflection for peaks as high as 4,000 volts direct current, or 1,500 volts alternating current. By the use of a double set of binding posts, together with a double throw, double-pole switch, the element may be switched quickly from a voltage recording position to a current recording position.

A decidedly novel feature of this new oscillograph is the elimination of the arc lamps and the substitution in its stead of a tungsten filament lamp. This feature will appeal to anyone who has had to operate oscillographs in the past by using the arc lamp with its heat, sputter, necessity of periodical adjustments, etc.

In order to obtain by means of the tungsten filament lamp a light comparable to that of the arc, a voltage greatly in excess of normal is impressed for an exceedingly short period. The lamp does not burn out until thousands of exposures have been made.

In the optical arrangement the novel features are: The focal plane, drum, shutter, and mechanical shutter release, the trip magnet and remote control switch and the lamp extinguishing switch. The double conductor passing to the driving head is in the trip magnet circuit. An adjustable contact, on the driving head, closes this circuit any desired fraction of a revolution ahead of the opening of the shutter. This should be set to equal slightly less than the time which will be required for the remote control apparatus to function. The length of the exposure depends on the speed of the photographic drum. With this apparatus the drum speed may be varied from about twelve hundred to sixty revolutions per minute, giving an exposure of from .05 second to 10 seconds.

For fast films the incandescent lamp is placed momentarily on a 60 per cent excess voltage, which, if continued, would cause the lamp to burn out in less than one second. Either a filament of a very heavy current (18 amperes or more) or a specially constructed ribbon filament is used. With the automatic lamp control of this oscillograph, thousands of films may be taken before burning out the lamp. For slow films which have been taken up to three-quarters of an hour exposure, the lamp needs but slight abnormal voltage.

With the special automatic control of the incandescent lamp and shutter it has been possible to take and develop nearly a hundred films in one day, for no readjustment of the oscillograph is needed when it is once set up for a particular test.

For moderate speed films (of one-half second exposure or over) any number of portable oscillographs can be operated simultaneusly and still be located in different stations and record the different local effects of the same transient started by the remote control switch of one of the oscillographs. The closing of one switch, which supplies the motors and lamps of the several oscillagraphs, would cause the motors to bring each photographic drum up to speed in about .1 second and also bring the lamps up to abnormal brilliancy and start the remote control apparatus so as to bring the transient on the film at the desired place.—J. W. Legg, *Electric Journal*, December, 1920.

THE KAPLAN HYDRAULIC TURBINE

The Kaplan high-speed water turbine, designed by Professor V. Kaplan of Brünn, Austria, is a development of the Francis type.

It is claimed that the inventor deserted the dogmatic theories adhered to in current practice, especially those resting on the conception of an "ideal fluid" which is never met with in practice, and disregarded all the rules based on the so-called theory of "water-filament flow." He, in his theory of turbine design, attaches as much importance to question of friction, which has been hitherto practically neglected, as has been done by others to the character of flow. According to his theory, other conditions being similar, it is the number of blades that has the determining importance. If it is too small, the flow of water suffers, and if it is too large, then the efficiency is reduced.

In an effort to create a turbine maximum speed, Professor Kaplan shortened as much as possible the length of the blades. Furthermore, he found that a large clearance does not harm in any way. This led him to locate the blades farther and farther back of each other until he obtained a runner having only actual flow. Finally, it is claimed that he succeeded by proper selection of the suction pipe in reconverting a large amount of the energy of the water at discharge into pressure. Contrary to what happens in a Francis turbine, the water flows throughout the runner in an axial direction, and the deflection of the water in the runner is eliminated. The guide apparatus is designed in the same manner as in the conventional Francis turbines, but the vanes are so arranged that the water discharges not only along the longitudinal edges, but also at the front edges. The guide wheel cover has been made flat.

The advantages claimed for the Kaplan turbine are as follows: (1) The turbine shaft can have its bearings located

nearer the center of gravity of the runner than is the case in the Francis turbine. This results in a stable, comparatively light construction, avoiding the difficulties due to unbalancing which are encountered in Francis high-speed turbines. (2) The runner is somewhat smaller in diameter than the draft tube at its narrowest place. This makes it possible to insert the runner into the casing both from the draft-tube side and from the guide wheel cover side, contrary to what is the case with high speed turbines, which can be installed only from the draft-tube side, which is not always easy to do. (3) The diameter of the runner boss can be kept comparatively small; likewise the free blade area is considerably smaller than in the Francis turbine. The weight of the Kaplan runner is therefore very much smaller, in fact, it is claimed to be on the average only about one-fifth of the weight of a Francis wheel of the same diameter. It has also a difficult method of holding the blades, as a result of which it is claimed that a Kaplan runner can be made in about one-fourth the time required to make a Francis runner. (4) The principal advantage of the new construction lies, however, in the fact that with a Kaplan turbine speeds become attainable which are beyond the capacity of the Francis turbine, in addition to which the efficiency of the turbine at various loads varies in a more advantageous manner than with the conventional turbines. These points are further elucidated.

It is important to have hydraulic turbines run at as high a speed as possible, because this permits a more economical utilization of the electrical generators usually connected to them; and it appears that the most economical speed of rotation for the generator is from 200 to 300 r.p.m. for power outputs of from 500 to 5,000 hp. and from 400 to 600 r.p.m for power outputs of from 100 to 500 hp. These speeds are beyond the range of Francis turbines unless the head of water is very large and the volume of water small. This results in uneconomical plants for low water heads, and as an illustration a calculation is given showing that in a low head plant with a turbine having an output at 5,000 hp. and running at 83 r.p.m., the generators at piece-time prices would cost about $37,000, while if the turbine could be run at 250 r.p.m. the cost of the generator would be only about $25,000. Furthermore, the high-speed turbine, all else being equal, would be built much cheaper than the low-speed machine. The low-speed machine is uneconomical from another point of view, namely, that where large volumes of water have to be handled, a large number of units have to be used since otherwise the velocity would have to be excessively low and the units excessively large. Numerous small units, however, are always more expensive than a few large ones.

The following unit speeds are given for the conventional types: 12 to 50 for Pelton wheels; 50 to 100 for Francis slow-speed wheels; 100 to 200 for Francis normal speed wheels; and 200 to 300 for Francis high-speed wheels. As compared with these, a very much higher figure is possible with the Kaplan turbine; the first of these turbines built in Sweden had unit speeds of from 500 to 600, the turbines tested at the Technical High School in Brünn, 900, and in recent tests speeds of 1,200 to 1,600 have been obtained with good efficiency.

Numerous brake tests show that the efficiency of the Kaplan turbine is not only very high but it is maintained high through wide variations of head and volume. It is claimed that this turbine will lead to an extensive utilization of medium and low pressure falls..—V. Kaplan, *Zeitschrift für das gesamte Turbinenwesen*, July 10 and 20, 1920. Also *Zeitschrift des Bayerischen Revisions—Verein*, May 15, 1920, pp. 71-73. Abstract of the latter—*Mechanical Engineering*, Sept., 1920, pp. 516-517.

ALUMINUM FOR TRANSMISSION LINES

M. DUSAUGEY describes in *Annales des Postes, Télégraphes et Téléphones* for September, 1920, the manufacture, qualities and use of aluminum for electric transmission lines. A Commission on Aluminum appointed in 1913 decided that the following rules should hold for commercial aluminum: (1) It should be 99 per cent pure. (2) For wires in suspension the breaking stress should exceed 20 kg./mm.² for wires up to 35/10 and should exceed 18 kg./mm.² for wires 35/10 to 50/10. The tolerance on strand diameter is 2 per cent, the tolerance on stress is 2.5 per cent. For aluminum used in machines and insulated cables the breaking stress should not exceed 9 kg./mm.² (3) The limit of elasticity for hard-drawn wire shall not be less than 11 kg./mm.² The extension at rupture of hard-drawn wire shall be 2 per cent, and of annealed wire 25 per cent. (4) The pliability shall be tested by bending through 180 deg. backward and forward round diameters as follows: For 1.0 mm. wire, 25 bends; 1.5 mm. wire, 20 bends; 2.0 mm. wire, 15 bends; etc. ()5 The resistance of annealed conductors shall be 2.89 microhms per cm.³ at 20° C., *i.e.*, 60 per cent copper conductivity. Conductivity of hard-drawn wire shall be 2.95 michroms. The temperature coefficient is taken as 0.00449 per 1° C. Tolerance on resistance, 1 per cent.

A comparison of aluminum with copper shows that the relative weight of aluminum to copper is 30 to 100 for equal section, 42 to 100 for equal heating by the same current, 50 to 100 for section of equal conductivity. At pre-war prices the saving in using aluminum becomes in these cases 55 per cent, 37 per cent and 25 per cent, respectively.

The increase of resistance due to high frequency currents is less in aluminum than in copper. Instead of using bronze, duralumin might be used. The author knows of only one aluminum-steel transmission line in Europe, namely, in the Dauphine, where a 60,000-volt transmission line at an altitude of 6,000 ft., made of 6 conductors, 3 being 112 mm.² section and the other 3 of 88 mm.² section, has lasted for two years with only two breakdowns; one due to the slipping of a support, the other due to an electrical contact with a low-tension wire. The use of aluminum steel lines with spans of 300 meters is suggested and a table of comparisons for such lines is given.—*Technical Review*, Jan. 4, 1921.

ELECTRO-SHERARDIZING

SHERARDIZING is one of the three processes for applying metallic zinc to iron and steel, the other two processes being hot galvanizing and zinc plating, both of which require the article to be carefully cleaned from dust and grease. Sherardizing, however, does not require such care, as the rust is penetrated by the zinc and the grease vaporizes. The work is usually cleaned by a sand-blast or a 16 per cent sulphuric acid pickling bath.

The work to be sherardized is packed into a drum with a small quantity of zinc dust, and the temperature raised sufficiently to vaporize the zinc, and in that state it penetrates beneath the surface of the metal. Sherardized articles can be bent and swaged without cracking or flaking off, and should be able to stand at least 100 hours of salt solution spray (specific gravity, 1.03) at 60° F. without sign of corrosion. There is a definite relationship between the temperature of the operation and the thickness of the zinc coating. It is therefore easy to obtain a suitable thickness, which is 0.002-0.0025 in. thick.

Where heat is supplied by electric power, there is a marked advantage in regard to accurate regulation of the temperature, cleanliness and convenience of operation. The most popular form of drum is one 24 by 24 by 40 in., operated at a temperature of 340° C. or 644° F. The current consumption is 53.5 kilowatts to bring the drum up to the required temperature, and 13.5 kilowatts to maintain it at 340° C. It usually takes about four hours to raise the temperature, and about three and a half hours to cool to 230° C., when the work may be taken out safely. There must not be a greater fluctuation than ±5° F. during the process.

The windings are contained in all four sides of the drum, and outside them is a packing of heat-insulating material. The current is supplied to three slip rings from carbon brushes.

Work which has been heat-treated cannot as yet be sherard-

ized, but the difficulty will doubtless be overcome in time.—*Machinery* (London), V. 16, p. 97, 1920. Through the *Journal of the Institute of Metals*, 1920.

CENTRAL STATION DEVELOPMENTS IN 1920

The central station output last year was 46,700,000,000 kw-hr., as nearly as can be estimated by the *Electrical World*. These figures represent an increased output over 1919 of 21.2 per cent and an increase in the revenue from the sale of energy of 19.2 per cent. Since 1914 the output has increased 178 per cent and the revenue has grown from $336,980,000 to $922,300,000, an increase of 174 per cent. Financial problems in this field overshadow all others. The needs for new capital are exceedingly great and the acquisition of it is difficult. Permits for water-power development alone, if they are granted, will tax the ingenuity and skill of manufacturers, executives and operators alike, for they involve 12,000,000 hp. and the expenditures of approximately $2,000,000 over and above the normal outlay for improvements and beteerment to existing generating and distributing systems. During 1920 about $400,000,000 of new money was raised by electric public utility companies for refunding and other purposes incident to the well-being and expansion of the business.

The growth of the industrial load has been phenomenal. A nation-wide survey indicates that 1,161,400 industrial motors were served by central stations in 1919 and the motor connected load is estimated at 12,930,000 hp. Energy sold to power customers has increased from 7,486,300,000 kw-hr. in 1914 to 22,046,400,000 kw. in 1919, or 57.2 per cent of the total output. In 1915 the energy sold to power customers was about 51.1 per cent of the total output, hence, the proportion of the total output has increased since by about 6.1 per cent.

Based upon a population of 110,000,000, central stations reach about 63,000,000, or 57 per cent of the population. Figuring 52 persons per dwelling there are about 13,000,000 dwellings in the territory covered by the central station lines of which 7,000,000 are wired. In all the states there are 21,000,000 dwellings. This leaves 6,000,000 dwellings adjacent to central station lines not now electrically wired, and 8,000,-000 more to which service must ultimately be extended.

Survey of Progress in Mechanical Engineering

Prepared Under the Auspices of the American Society of Mechanical Engineers

PROBLEMS AND PROBABLE FIELD OF THE OIL ENGINE

By Paul Rieppel

The author starts with the discussion of the economical and political problems connected with the control of the world's supplies of oil and of the application of the oil engine by which he means the various types of internal-combustion engines, the Diesel and its modifications being considered in the first place.

In the course of his article the author makes many interesting observations and raises several questions well worth attention.

COMBUSTION PROCESSES

As regards the nature of combustion processes in the Diesel engine our knowledge has reached the point where we can clearly distinguish the processes of injection, vaporization, gas formation and combustion. The author believes, however, the very wide field in this domain remains as yet unexplored and that more work should be done in the laboratory by the physicist, such work being preferable in many cases to extensive experimentation on actual engines.

The most rapid and complete combustion is a function of the fineness of atomization, intermixture with air, and, to an extent which has not yet been fully appreciated, of turbulence. No thorough tests have been made to determine what is the best method to obtain the most complete atomization and what fineness of atomization is needed under each set of conditions.

What is the influence of catalysis in the cylinder, whether that due to presence of water or of some other catalytically acting material? The tests of Stein contain valuable material, but the influence of very small, in fact extremely small, amounts of water on fuel combustion remains as yet to be investigated. As a matter of fact, we know that under certain conditions very poor oils burn better in the presence of water and the use of other catalytic agents, such as silicon and various metals may bring startling developments in engine design and offer a means of increasing our available ability to control combustion.

How may we obtain the best possible conditions of turbulence and how to evaluate the influence of turbulence are questions which may be answered by tests on self-ignition of oils and the velocity of flame propagation therein. In a bomb oil vapor at rest does not ignite at all at temperatures corresponding to the temperature of compression in a Diesel engine, but when a slight turbulence is produced, as, for example, by blowing in some air, self-ignition takes place. Comparatively little has been done in this direction. This and other questions must be considered by everyone interested in the subject of combustion processes, and they are not mere academic problems but important stones in the foundation of which the structure of economic design of an engine has to be raised. Had we had this information a highly economic Diesel engine could have been designed long ago and have done away with the compressor.

From this the author proceeds to the discussion of various attempts to build a Diesel engine without a compressor, such as have been proposed by Vickers, Price and Steinbecker engines.

ECONOMY OF OPERATION

In the determination of the economy of operation the questions as to the use of a 4-stroke and 2-stroke cycle, high or medium pressure, are questions which lie at the foundation of the problem. After discussing briefly the relative position of the 4- and 2-stroke cycles and the question of scavenging, the author proceeds to the question of compression and asks whether we shall continue to operate Diesel engines with a compression of 35 atoms. and the heavy weight of the engine and mechanical difficulties which it involves.

The higher thermal efficiency secured with this compression does not have decisive value in the author's eyes, as motors employing lower compression pressures would have a lower first cost, be more reliable and show a better mechanical efficiency. As regards the advantage secured through self-ignition of the mixture, it is pointed out that the point of self-ignition goes down very materially when the cooling produced by the expanding stream of the air of injection is eliminated. With solid injection every condition of engine operation can be met without external means of ignition at a pressure of 25 atmos., but even assuming that self-ignition would have to be dispensed with: Why not? The high value placed on the ability of the engine to operate on a basis of self-ignition is a survival of a time when electrical ignition was still complicated and unreliable. Today it is quite easy to provide reliable means of producing a good electric spark having a good control of

timing, or, where necessary, to produce a wire spirally maintained at the blowing heat all the time by a flow of electric current. There is no reason why one should not employ outside methods of ignition in engines in which the most economical operation may be secured at compressions at which self-ignition can no longer be relied upon.

In connection with the problem of securing the most economical operation of oil engines, the author takes up the question of utilization of waste heat. It is true that as high as 40 per cent of the heat in the fuel may be usefully employed in the oil engine but this is no reason why one should waste the other 60 per cent without any effort at recovery. The comparison with the 12 per cent heat efficiency of the steam engine is often misleading because in a steam engine a good deal of the heat in the exhaust steam may be still utilized for purposes of heating and drying. In properly conducted factory processes employing steam, the power generated by the steam engine should be considered as a mere by-product, while in the case of oil-engine drive it is the main if not the only product of fuel combustion.

The problem of utilizing the waste heat of oil engines is one of the most important from an economical point of view. The usual way is to pass the exhaust gases on to steam boilers, a method well known in large gas engine operation. This cannot be employed as conveniently with oil engines, because the temperature of exhaust gases is considerably lower. Furthermore, any attempt at a thorough utilization of exhaust heat in oil engines would involve a considerable increase in the first cost of the installation and also possibly corrosion troubles due to the presence of sulphurous acid in the exhaust gases. In particular, in the case of auxiliary boilers on shipboard, it has been found advisable to equip them with direct oil heating in addition to heating by exhaust gases. An important physical problem is the determination of the coefficient of heat transfer from exhaust gases to the boiler wall. There is a question proposed by Nulfelt, but, in general, the coefficients now employed are more or less of a rough case and do not take into consideration many important factors.

In this connection attempts may be mentioned to mix the exhaust gases with steam and to add to them compressed air and utilize the mixture either in turbines or in reciprocating engines. It does not appear that any such efforts may lead to useful conclusions.

In another part of the same article, which will be abstracted at an early date, the author discusses the application of oil engines, in particular those operating on heavy oils as opposed to gasoline and kerosene engines to various specific purposes, such as driving of locomotives, road vehicles, tractors and aircraft.—*Zeitschrift des Vereines Deutscher Ingenieure*, Vol. 64, Nos. 49 and 50, Dec. 4 and 11, 1920, pp. 1021-1027 and 1051-1055.

WORK SPEEDS IN CYLINDRICAL GRINDING

By Robert J. Spence

The author claims that the importance of the function of the speed-changing device in grinding machines does not seem to be understood in general by the operators, of whom a very large number believes that the faster the work revolves the greater the amount of work produced. The author believes this is erroneous and that to operate a grinding machine continually on the fastest work speed is just as wrong and just as wasteful as it would be for a lathe operator to run his machine continuously at a filing speed when turning work.

To prove this, the author analyzes a case where a man is grinding a bar of steel and using the fastest work speed and fastest table traverse with which the machine is equipped. He shows that when an excessively high speed is used only part of the wheel face is presented to the work, and when such a thing happens the remaining part simply laps over on the surface ground during the proceeding revolution of the work and there is a non-uniform wearing action. The portion of the wheel face which is not cutting but simply dragging on the work becomes glazed and adds useless friction to the operation, thus increasing the power consumption of the machine.

The importance of using the greatest possible radial depth of cut is discussed next. Even a small increase in the radial depth of cut permits for the same amount of work to reduce the number of table traverses which, for the same rate of traverse, means a material reduction in the time consumed in grinding a piece.

The question of the effect on the amount of stock removed in its relation to wheel wear when the speed of grinding is reduced, is also discussed in some detail on the basis of the graphic analysis of the action of a grinding wheel proposed by Prof. George I. Alden. A discussion of the numerical case indicates that in that instance a change of work speed from an excessive rate of 190 r.p.m. to a more rational speed of 75 r.p.m. increases the amount of stock removed per unit of wheel wear 150 per cent.—*Machinery*, Vol. 27, No. 5, Jan., 1920, pp. 438-440.

WATER PURIFIER IN VERTICAL BOILER

In locomotive cranes the item of washing and maintenance work on the boiler is of great importance, especially on contract work where such water has to be used as is available.

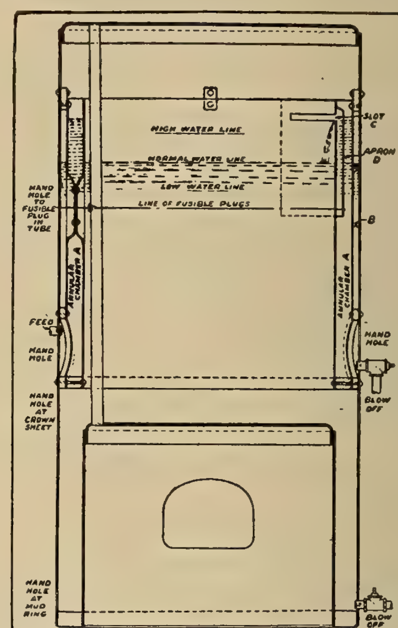


FIG. 1. PARKER LOCOMOTIVE CRANE VERTICAL BOILER WITH WATER PURIFIER

The locomotive crane boiler has been placed on the market equipped with an annular scale chamber located between the tubes and the shell plate, Fig. 1.

The feedwater is passed through this scale chamber at about 1/200 of the speed through the intake pipe and attains a temperature at which the scale-forming impurities are liberated from solution without the use of any chemicals. The impurities are then carried in suspension and as the movement of the water is very slow these suspended precipitates settled down readily to the bottom of the chamber. This settling is accelerated by the decrease in density of the water as it is heated and by the decrease in its fluid friction.

The purifier consists of the annular scale chamber A extending completely around the tubes with a 1-in. water space B between this chamber and the boiler shell. The outlet into the main portion of the boiler is the slot C guarded by the apron D. The feedwater is admitted directly to the scale chamber A at a point farthest from the outlet slot. It travels slowly around this chamber to the outlet and reaches approximately the boiler temperature before overflowing. The apron D keeps any floating impurities, such as grease, oil, etc., from being discharged into the main boiler.

As regards the efficiency of this purifying device, it is stated that in one test of a 42-in. diameter boiler of this type, at Pat-

erson, N. J., a feedwater naturally carrying 5 grains per gal. was loaded with 70 grains of calcium and 70 grains of earth, a total of 145 grains per gal. The feed was taken from a barrel agitated with carbonic acid gas to form calcium carbonate. After about 1,200 gal. of this kind of water had been passed through the boiler, it was allowed to cool and the heating surface and lower mud ring were found to be perfectly clean and the mud was about 6 in. deep in the scale chamber. The blowoffs were both plugged so that all impurities remained in the boiler.—*The Iron Trade Review*, Vol. 68, No. 4, Jan. 27, 1921, p. 293.

SAND BLASTING

By C. W. Starker

A practical article describing the types of apparatus abrasives, nozzles, air pressures, dust exhausting and general methods of operating.

There are several systems of sand blasting differing in the manner of applying the stream of abrasive to the surface to be treated. Air compressed to varying pressures is commonly employed in all sand-blasting equipment, but the pressure is applied in different ways.

In the direct pressure system the air and the abrasive are combined in and discharged from a closed tank through a nozzle. In the suction system the abrasive is carried to the nozzle by the suction created by a jet of compressed air, which, in passing through the nozzle carries the abrasive with it. This system is also known as the siphon system. For this system the apparatus used like the sand-blast gun is employed. In the third system, known as the gravity system, the abrasive is carried by mechanical means to a place above the nozzle and is fed down by gravity.

In general it may be said, other things being equal, that the higher the air pressure used the stronger the forces of the jet discharged against the surface to be treated, and therefore the greater the amount of work done. It may be roughly stated that according to actual practice 50 lb. air pressure will perform twice as much work as 20 lb., or 65 lb. will accomplish twice as much as 30 lb., and 72 lb. twice as much as 40 lb. The air pressure used for different materials are as follows (fair average practice): Steel castings or forgings, 80 to 100 lb.; malleable iron, 70 to 85 lb.; and iron, 60 to 70 lb.; and brass and aluminum, 35 to 50 lb.

The volume of air flowing to a nozzle opening at a given pressure is governed by the size of the nozzle. (Table 1). As the nozzle is apt to wear, however, it is important to design it so as to reduce this wear as much as possible. Moisture in compressed air prevents an even flow of abrasive and causes the sand to form lumps. It is also deterimental to pneumatic tools which are operated from the compressed air system.

As regards the abrasive materials, sand is the most commonly used on account of its relatively low price. Ordinary lake or river sand is inferior to sea sand and silica sand. Abrasive, such as steal grit and shot, are used to a certain extent, but are not suitable for work such as electroplating or galvanizing, as the adherence of metallic dust prevents the success of the final process. All abrasives should be screened each time before using to remove particles large enough to plug the nozzle and also to eliminate fine particles which only produce dust and have no abrasive quality.

It is important to have the sand blast rooms well ventilated. In the majority of cases it is also necessary to provide methods for gathering and settling the dust rather than discharging it into the atmosphere.—*Machinery*, Vol. 27, No. 5, Jan., 1921, pp. 458-462.

Table 1. *Flow of Free Air for Different Sizes of Nozzles*

Diameter of Nozzle, Inches	Pressure (Cubic Feet per Minute) and Corresponding Horsepower Required														
	20 Pounds	HP.	30 Pounds	HP.	40 Pounds	HP.	50 Pounds	HP.	60 Pounds	HP.	70 Pounds	HP.	80 Pounds	HP.	100 Pounds	HP.
1/8	7.70	0.63	10.00	1.03	12.30	1.50	14.50	1.99	16.80	2.57	19.00	3.19	21.20	3.86	25.73	5.33
3/16	17.10	1.40	22.50	2.32	27.50	3.26	32.80	4.40	37.50	5.74	43.00	7.22	47.50	8.65	57.88	11.98
1/4	30.80	2.53	40.00	4.12	49.10	5.99	58.20	7.99	67.00	10.25	76.00	12.77	85.00	15.47	103.00	21.32
5/16	48.17	3.95	62.89	6.48	76.60	9.36	90.70	12.43	105.00	16.07	119.00	20.00	133.00	24.10	161.00	33.82
3/8	69.00	5.66	90.00	9.27	110.00	13.42	130.00	17.81	151.00	23.10	171.00	28.73	191.00	34.76	232.00	47.90

Progress in Mining and Metallurgy

Abstracts of Papers and Recent Articles

Prepared Under the Auspices of the American Institute of Mining and Metallurgical Engineers

THE ELECTRIC FURNACE IN THE IRON FOUNDRY

By Richard Moldenke

One of the gravest problems of the iron foundry today is the accumulation of sulphur in commercial scrap and its effect on the castings made therewith.

In the ordinary cupola remelting of pig and scrap, at least 0.02 per cent sulphur is taken up; often double that amount.

Until the advent of the basic-hearth electric furnace, the only method of holding the sulphur within reasonable limits was to use high percentages of pig in the foundry mixtures. Pig iron seldom contains over 0.05 per cent sulphur, if well made.

Before the iron foundryman, particularly the producer of gray and malleable iron castings, can pour his molds safely, the molten metal must have a high degree of superheat, be thoroughly deoxidized, and reasonably low in sulphur. A foundryman will get these characteristics if he uses good materials and melts properly. The electric furnace will give a highly superheated metal that is thoroughly deoxidized, and a fine degree of desulfurization if the hearth is basic.

The foundryman may melt cold metal directly in the acid or basic-hearth electric furnace, or he may refine molten cupola or furnace metal in either hearth or electric furnace. The problem of the electric furnace in the foundry resolves itself into either adding the necessary electric equipment for duplexing, or installing electric furnaces for direct melting and refining of cold stock. Of the two hearth systems the basic is to be preferred for its specific value in desulpherization.

Electric furnaces of large tonnage are expensive, a 3-ton outfit, which ordinarily would be considered quite large, costs about $35,000 at this writing. For a moderate degree of refining—that is superheating, deoxidation and desulfurization—the metal, as taken from the cupola, should remain in the electric furnace at least ½ hr. With rapid repairs after

tapping out, fully ¾ hr. will be required for each batch of molten metal. For an average foundry, melting say 20 tons daily in a 54 in. cupola, the heat will last 2 hr., which permits the treatment of only half of it by the duplex method. Unless the product of the establishment can be divided into high-grade and ordinary work, the duplex process will be difficult to install with the present daily routine. Foundries can do this in most cases, hence an electric-furnace equipment added to the ordinary foundry will work out very nicely.

The selection of the basic-hearth electric furnace involves several considerations. In the acid-hearth furnace, the slag situation is easier, deoxidation is readily accomplished by providing a slag cover with additional periodic charging of fine coke on this to hold the furnace atmosphere neutral. The intense heat of the bath, with its high carbon percentage, takes care of all oxygen that may be in the metal in some combination. The disadvantages of the acid-hearth furnace are that, whether melting cold metal or duplexing, it is necessary to start with comparatively good material, as the sulfur question remains. Further, there is a marked addition of silicon in the bath by reduction from the silica hearth and slag, if refining is carried on for any length of time. The advantages of the acid-hearth are the cheaper refractories required, the furnace body lasting as long as an open-hearth furnace and in much easier slagging conditions. Where, therefore, the question of extremely low costs is not so serious an item, there is no reason why an acid-hearth electric furnace should not be used for melting from cold metal, for the sulfur can be held down by using high percentages of good low-sulfur pig iron—the melting process gives no additional sulfur, as is the case in cupola melting.

In view, however, of the sulfur conditions in purchased scrap and the desirability of holding down the sulfur maximum, the basic-hearth electric furnace should be used in every new installation, whether for cold melting or duplexing.

COAL PILLAR DRAWING METHODS IN EUROPE

By George S. Rice

Some form of longwall mining is generally used in Continental Europe; also in Great Britain where the coal is weak and friable, or the coal bed provides material for pack walls and filling, or where the bottom is soft and squeezes up easily, or the roof is pliable, or the bed is thin and brushing provides building material, or the thick multiple seams are mined in layers, such as the 24-ft. seam at Weymiss, Scotland, or the 10-yd. pitching bed near Coventry, England. But pillar methods have been retained in British fields where the coal beds are from 5 to 9 ft. thick, and free from thick partings or binders or without draw slate, which would provide waste rock for pack walls, or where the roof is hard and requires shooting to bring down and the bottom or floor is comparatively hard.

The room-and-pillar system, by which probably 95 per cent of the coal of the United States is produced, is now found in only a few mines in Wales, where it is known as the pillar and (single) stall method. The American room-and-pillar system is not equivalent to the bord-and-pillar or stoop-and-room system.

The bulk of the coal mined in Europe comes from a depth of more than 1,200 feet., while the deepest mines in Great Britain, Belgium, and France reach 3,500 to 4,000 feet.

It is generally conceded, without reference to the cost of production, that the larger the pillars left on the first mining, the more thoroughly can the coal be extracted. In Europe complete extraction is generally compelled either by the lessors or by the governments; whereas in this country, it has been more largely a question of competitive cost of production, or the support of the surface in the flat farming districts of the Middle West, that has determined how completely the coal is to be extracted.

Systems employing pillars, used in Europe, may be classified as follows: Pillar and (single) stall; pillar and double stall; square chamber method of South Staffordshire; bord-and pillar, or, stoop and room; rooms or bords hydraulically sand-filled.

In Upper Silesia, room-and-pillar methods of ordinary type were used extensively in beds 10 to 60 feet thick; but owing to extensive fires and trouble from subsidence of surface and generally poor recovery of coal, these methods have been supplanted by longwall and hydraulic-sand filling methods.

SUMMARY

1. In Europe, only a small proportion of the coal production is obtained by mining systems employing pillars other than shaft pillars under buildings, or barrier pillars.
2. Pillar systems are employed to a limited extent in Great Britain and in connection with sand-filling in Upper Silesia.
3. The typical American room-and-pillar system is not employed in Europe except in a few places in Wales.
4. The principal pillar system, where it is used at all, is the bord-and-pillar, in which the pillars are extensive, compared with the area taken out by the preliminary bords and headways, in general not over 10 or 15 per cent of the coal is taken out in advancing.
5. In its best form, the bord-and pillar system permits a recovery of 95 per cent of the coal, by what is practically a retreating longwall method.
6. The pillars are extracted by successive splitting or slicing.
7. The bord-and-pillar system is applicable only where the coal and roof are relatively strong and the coal is free from large partings, and there is no draw slate which requires gobbing.
8. The American room-and-pillar system approaches the bord-and-pillar where the rooms are narrow and the pillars wide and the retreat is carried on a diagonal line, as in mines of the Connellsville district of Pennsylvania, and in some of the deep mines in the Rocky Mountain region.

SKIP HOISTING FOR COAL MINES

By Andrews Allen and John A. Garcia

The superiority of skip hoisting in metal mining is shown by its almost universal adoption.

By varying the size of skip and the rope speed, any desired hoisting tonnage can be secured and, since only one kind of material is handled and breakage is unimportant, the loading of the skips can be easily and cheaply effected from bins into which the cars are dumped. The cars may then be designed to fit the conditions in the mine instead of being a compromise between hoisting and mining conditions, very likely suiting neither.

In coal mines, the usual practice has been to hoist the car to the surface, either on platform or self-dumping cages. Of late years the number of skip-hoisting plants in coal mines has been rapidly increasing, but there is more or less inertia to overcome in establishing so radical a change in practice, also the earlier skip operations were not uniformly or completely successful. As a result it became evident that metal mining practice would require radical modification before skip hoisting could be successfully used in coal mining.

OBJECTIONS TO SKIP HOISTING—BREAKAGE

Except where coal is used for coking or other purposes where breakage is unimportant, the breakage of the coal is of vital importance all the way from the face to the railroad car.

The difficulty of inspection and docking, in the opinion of the writers, is one of the most serious objections to skip hoisting, yet it is easily overcome. In a large mine it is impossible to examine and dock each car separately. The effort of mine managements should be directed to securing clean coal at the face, and the only practicable method of checking the loaders is to employ a "spotting system," by means of which a certain number of cars, taken at random or from sections of the mine where careless loading is suspected, can be taken

out, carefully and thoroughly inspected, and the docks identified and charged against the guilty loader.

Where the coal is dumped indiscriminately into a deep pit, no docking or spotting system is possible, except through the use of an auxiliary shaft; but where a skip installation is properly designed, it is just as possible to dock with a skip as with a cage, and without any greater inconvenience or sacrifice of output.

It is possible, in a skip mine, to provide an excessive hoisting capacity, which will take care of the rock, as well as the coal; where the deep pit is not used, the design can be easily arranged so that a moderate quantity of rock can be handled at the main hoisting shaft without the slightest difficulty.

A skip will not handle men or material unless equipped with an auxiliary deck, in which case it becomes cumbersome and inconvenient.

The advantages of skip hoisting are:

A hoisting capacity, capable of taking care of all the coal and rock that can be mined.

A smaller shaft.

A large ratio of lading to gross weight.

STATIC AND DYNAMIC TENSILE TESTS ON NICKEL STEEL

By J. J. Thomas and J. H. Nead

This investigation was undertaken to determine, if possible, the relation between static and dynamic tensile tests as measured by the work required to break test specimens slowly, in a tensile testing machine, and rapidly, by means of a falling weight. It was hoped that the investigation would throw some light on the rôle played by ductility under different rates of application of load.

Results indicate that more work is required to break a specimen under a rapidly applied load than under one slowly applied.

Nickel steel that has been quenched but not drawn, or drawn up to 300° C. is very brittle, and required very little work to break it under either a rapidly or slowly applied load.

The ductility is independent of rate of application of load.

As work is the product of force and distance, we must conclude that as the elongation is the same and the work is greater, the resisting force of the metal is greater for suddenly applied loads.

For a slowly applied load this metal was hard and brittle when drawn at temperatures of 300° C. or lower. Beyond this point, however, a real softening effect is obtained. For low drawing temperatures, the maximum strength, yield point, and elastic limit, or limit of proportionality, occur at the same point, thus giving a brittle steel that fails without warning. This may be due to internal strains that have not been removed, or to the hard martensitic structure of the steel. For higher drawing temperatures there is a marked increase in the ductility and a greater resistance to shock.

CONCLUSIONS

For hard steels the total work of rupture is very low under either a slowly or a rapidly applied load.

The modulus increases slightly with the higher drawing temperatures; this increase is probably too slight, however, to have a commercial value.

If we could be absolutely sure that the applied stresses would never exceed the elastic limit, and that the steel would never be subjected to a live load, we could use a hard steel, and with a smaller area obtain the same resisting force of a soft steel, due to the higher elastic limit. In most problems of design, however, live loads will be encountered, either during the fabrication of the material or in service.

Hard steels require little work for rupture; therefore, any small suddenly applied load would be sufficient to cause fracture.

For the low drawing temperatures both the ductility and the work of rupture are very low. As ductility increases, the work of rupture increases. For hard steels, therefore, a small force, less than the elastic limit, if applied with sufficient velocity, will develop enough kinetic energy to cause rupture.

It is evident that force alone is not the proper criterion by which to measure the strength of material. The work unit is more valuable as a measure of strength, and as ductility is an indication of the work required to rupture, it is wise to specify a higher ductility for all parts subject to shock.

Ductility, as measured by elongation and reduction of area, in the ordinary tension test, is important, therefore, not for the part it itself plays but as an indication of strength as measured by work units. Steel is in its best condition when quenched and drawn just under its critical temperature.

ALASKAN COAL FIELDS

By George Watkin Evans

Many areas of coal-bearing rocks are widely distributed geographically from Cape Lisburne, on Bering Sea, to Admiralty Island south of Juneau. Bituminous coal is found at Cape Lisburne, on the Bering Sea, at Five Finger Rapids on the upper Yukon, and at Herendeen Bay and Chignik Bay; lignito is found on the Kobuck River, along the Yukon River from points near the mouth to Tonakat, near Rampart, at Dawson; on the east shore of Cook Inlet and in the Tanana Valley 50 miles south of Nenana.

The Susitna and Matanuska Valleys contain coal ranging from lignite to anthracite, and in the Bering Lake district there are coals ranging from semi-bituminous to anthracite.

TOTAL COAL AREAS IN THE ALASKAN COAL FIELDS

It is estimated, by Stephen Capps of the United States Geological Survey, who mapped the Nenana coal field, that 165 square miles of land are underlain with coal-bearing strata in that district.

Dr. George C. Martin, of the United State Geological Survey, estimates that there are 54 square miles of supposed coal-bearing formations in the Matanuska field proper and that probably an additional 24 square miles might be regarded as extensions of supposed coal-bearing areas. The area between Eska Creek and Moose Creek undoubtedly contains a large tonnage of minable coal, but the area between Chickaloon and Kings River is somewhat doubtful; at least the more recent work done in this part of the field indicates considerable doubt as to the continuity of the beds between these two places. Work is being done at the present time by the United States Navy to demonstrate the amount of minable coal in the area lying between Chickaloon and Kings River. An additional area of coal bearing strata lies eastward of Chickaloon and it is probable that, with further development, additional areas of high-grade coal will be found within this district.

The Kachemak Bay field contains a large total area of coal-bearing strata. The coal bearing formations appear to extend to the eastward from Bluff Point to the head of Kachemak Bay and to the northward along the northeast shore of Cook Inlet for a considerable distance.

The Bering River field contains approximately 22 square miles of coal-bearing formation in the bituminous portion of the field and perhaps 25 or 30 square miles of coal-bearing formation in the anthracite part of the field. Of the 20 square miles or more of coal-bearing strata in the bituminous area, only a comparatively small portion will prove to contain coal that can be mined at a reasonable cost, for which reason the total tonnage of minable coal within this portion of the field will be much less than is generally supposed. The same is true of the anthracite part of the field.

Exploitation of the Alaskan coal fields began about 1903 and development continued, in a small way, in the Bering River field until 1908, when President Roosevelt withdrew the Alaska coal lands from entry. Some development work had been done in the Matanuskan coal fields and a small amount of work had been carried on in the Kachemak Bay field. Since 1915,

it has been possible to lease coal land in both the Matanuska and the Bering River fields; the Kachemak Bay and the Nenana coal fields have more recently been subdivided into leasing units.

Three attempts were made by private lessees within the Matanuska field to develop commercial coal mines, but all three failed. The Government has taken over one of the leases to supply the needs in railroad construction.

Several attempts have been made in the Bering River field to develop profitable coal mines. It appears that one or two of the companies in this field will develop coal mines of small production which will probably pay to operate. Taking the investment in this field as a whole, the coal mining venture has been a loss. Instead of retarding private development in any of the Alaska coal fields, the Government should have encouraged legitimate development. The Government has assumed the latter attitude during the past few years.

Correspondence

The editor is not responsible for statements made in the correspondence column. Anonymous communications cannot be considered, but the names of correspondents will be withheld when so desired.

A METHOD OF BALANCING CHEMICAL EQUATIONS

To the Editor of the SCIENTIFIC AMERICAN MONTHLY:

One of the exercises of the student of chemistry is the writing of chemical equations, which are succinct statements by means of numbers and symbols, expressing the chemical transformations in a given reaction, as also the quantitative relations of the substances involved in the change. The interacting substances, written on the left-hand side of the equation, are called the factors, the resulting new substances, written on the right-hand side, are called the products. It has long been known that the weight of the factors equals that of the products, that is to say, in chemical changes, matter is neither created nor lost, but only transformed.

These well established facts justify that process which the student resorts to, called the balancing of chemical equations. After having ascertained, either by his own experimentation, or someone's else all the factors and products, he writes the preliminary equation, making sure that the formula of each substance is correct, though without the numerical coefficients before the formulas.

His next step is to balance the equation, that is, so choose the coefficients, that the number of atoms of each element on either side of the equation shall be equal. Every teacher and student of chemistry has no doubt experienced some difficulty at times, and very often has consumed much valuable time in this last operation. This, of course, is not the case, when the reactions are simple, since mere inspection will at once suggest the proper coefficients to be placed before each of the factors and products. In proportion, however, as the reaction becomes more complex, inspection becomes more difficult, and the method of trial coefficients must be invoked, which involves a certain amount of guess-work, with the consequent uncertainty and loss of time.

When such difficult equations arise, we may use the method, described below, which very often will take the guess out of the problem of balancing chemical equations. The method is based on the principle that a chemical equation conforms in some respects to the algebraic equation, and hence the algebraic process may be legitimately used. This does not mean that all algebraic processes may be used, because the two kinds of equations do not conform in all respects.

Let us take as an example the following reaction, in which the required coefficients are indicated by letters:

$$aCrCl_3 + bNaC_2H_3O_2 + cH_2O + dCl = eNaCl + fH.C_2H_3O_2 + gNa_2CrO_4.$$

As the number of atoms of each element on the left-hand side must equal the number of the same element on the right, it follows that we may write the following equations:

For Cr: $a=g$ (1)	For C: $2b=2f$ (4)
For Cl: $3a+d=e$ (2)	For H: $3b+2c=4f$ (5)
For Na: $b=e+2g$ (3)	For O: $2b+c=2f+4g$ (6)

Assume a value 1 for a, and we have: $a = 1$; whence also $g = 1$.

From (4): $b=f$.
Then (6) becomes: $2b+c=2b+4$. Whence $c=4$.
Then (5) becomes: $3b+8=4b$. Whence $b=8$.
Therefore also: $f=8$.
Then (3) becomes: $8=e+2$. Whence $e=6$.
Then (2) becomes: $3+d=6$. Whence $d=3$.

Substituting these values in the original equation, we have:

$$CrCl_3 + 8NaC_2H_3O_2 + 4H_2O + 3Cl = 6NaCl + 8H.C_2H_3O_2 + Na_2CrO_4$$

Since it is more accurate to write $3Cl_2$ than 3Cl, the equation may be so corrected by multiplying each coefficient by 2.

It sometimes happens that the solution of the simultaneous equations involve fractional values. In such cases the fractions may be got rid of by multiplying each number by a suitable integer. For example, in the following reaction:

$$aCu + bHNO_3 = cCu\ (NO_3)_2 + dH_2O + eNO.$$

After solving as above we have:

$a=1$; $b=8/3$; $c=1$; $d=4/3$; $e=2/3$.

Multiplying by 3 we have: $a=3$; $b=8$; $c=3$; $d=4$; $e=2$.

P. F. GALTES.

Mt. St. Michael's, Hillyard, Wash.

APPEARANCE OF THE FUR HAIRS OF VARIOUS MAMMALS

IN last month's issue of SCIENTIFIC AMERICAN MONTHLY on page 131 there appeared an engraving showing the microscopic appearance of fur hairs of various mammals. In each figure two hairs were shown; one treated to show the cuticular scales, and the other to show the medulla. While the engraving served to show variations of different fur hairs the animals from which they were taken were not designated, and as this information will undoubtedly be of value to our readers we give here a list of the animals, prepared by Dr. Leon August Hausman. The numbers following each name are the diameters of the hairs in micra:

Fig. 6. Ermine (*Putorius erminea*)—17
Fig. 7. Mink (*Putorius vison*)—11
Fig. 8. European Otter (*Lutra vulgaris*)—10
Fig. 9. Wolverene (*Gulo luscus*)—25
Fig. 10. Fitch (*Mustela putorius*)—18
Fig. 11. Koala (*Phascolarctos cinereus*)—22
Fig. 12. Duckbill, or Platypus (*Ornithorhynchus anatinus*)—8
Fig. 13. Rabbit (*Lepus nutalli mallurus*)—17
Fig. 14. American Gray Squirrel (*Sciurus carolinensis*—(18
Fig. 15. Chinchilla (*Chinchilla lanigera*)—16
Fig. 16. Woodchuck, or Marmot (*Arctomys monax*)—22
Fig. 17. Muskrat (*Fiber zibethecus*)—17
Fig. 18. European Mole (*Talpa europaea*)—17
Fig. 19. American Mole (*Stalops aquaticus*)—17
Fig. 20. Raccoon (*Procyon lotor*)—20
Fig. 21. Opossum (*Didelphys virginiana*)—37
Fig. 22. Nutria, or Coypu rat (*Myocastor coypus*)—11
Fig. 23. Red Fox (*Vulpes pennsylvanicus*)—19
Fig. 24. Black Bear (*Ursinus americanus*)—27
Fig. 25. Canada Lynx (*Lynx canadensis*)—19
Fig. 26. Civet (*Arctogalidia fusca*)—21
Fig. 27. Skunk, or Marten (*Mephitis mephitica*)—26
Fig. 28. Hair Seal (*Otaria jubata*)—105 (protective hair)
Fig. 29. Badger (*Taxidea americana*)—57

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MODERN FIRE FIGHTING EQUIPMENT—A MEMBER OF NEW YORK'S RESCUE SQUAD SHUTTING DOWN A REFRIGERATING PLANT IN A CELLAR FILLED WITH ESCAPING AMMONIA FUMES (SEE PAGE 329)

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THE SINGING PIPE ORGAN

REGULAR readers of the SCIENTIFIC AMERICAN MONTHLY undoubtedly realize that the importance of an article, appearing in this journal, cannot always be judged by the prominence of its position. It so happens that in the present issue the last article in order of position is one of the most interesting. Lest those who are not mathematically inclined be frightened by the appearance of a few formulæ, and pass the article by, we take this occasion to recommend to their particular attention Professor Scripture's paper on the "Nature of Vowel Sounds."

Professor Scripture had for his aim to produce a church organ which would be of material assistance to the choir and the congregation. It is a well-known fact that many singers are very careless in pronouncing consonant sounds. Most of the consonants are so short and of such an explosive nature that it is very easy to lose them completely in singing, so that what the audience hears is mainly a succession of vowel sounds. If the hearer is familiar with the music and the words he supplies mentally what his ear does not actually hear. Thus the choir may be singing "oh-ee oh-ee oh-ee aw aw aw-ai-ee"—at least this would be the impression upon a foreigner—but the congregation, being familiar with the air and with the words, would mentally translate the sounds into "Holy, Holy, Holy, Lord God, Almighty."

Since the consonants are of secondary importance, Professor Scripture hit upon the idea of fitting the pipe organ with a vowel-sounding register. In other words, he would provide resonators which would respond to the different vowel sounds so that the organ, instead of producing pure musical notes, would actually sing these vowels, thereby assisting the choir and the congregation. This research led to the investigation of the nature of the vowel sound, and efforts were made to determine why one voice is more musical than another.

Vowel sounds according to Helmholtz are produced by smooth vibrations with harmonic overtones, but recent investigations confirm an earlier theory first published by Willis in 1830, to the effect that the fundamentals in vowel tones are constructed of series of puffs and inharmonics. Professor Scripture produced his tones with a siren, which, as is well known, cuts a jet of air into a succession of puffs. In connection with this, he used soft resonators in imitation of the mouth and was able to obtain resonators which would respond to various vowel sounds at any pitch. In the human voice these puffs are produced by the larynx and the musical quality of the voice depends solely on the presence or absence of various qualities in these puffs. To quote Professor Scripture, "The quality of the voice that distinguishes a Caruso from a costermonger lies exclusively in the laryngeal puff." This is rather upsetting to the theory heretofore held that the resonance of the vocal cavities give the musical quality to the tone. Professor Scripture also brings out the interesting fact that every vowel sound has a melody of its own which varies with the emotion of the singer. In examining records of Caruso's voice he finds that he never keeps on a constant pitch during a vowel, but is continually making slight changes which express emotion, such as sadness, admiration, doubt, etc.

WHAT IS LUBRICATION?

SCIENCE has been likened to a complex puzzle picture, which learned men are painstakingly putting together out of a vast multiplicity of blocks known as "theories." Many blocks are tried and rejected before one is found that fits perfectly into its surroundings. Sometimes in despair of getting a perfect fit, a block which is a partial fit is used tentatively in the hope that other blocks may be found to fill up the chinks around it, or that later discoveries may call for changes in the surrounding blocks, which will make them conform to the outline of the apparent misfit. The more perfect the fit, the surer we are that our theory is correct, but we may never be *perfectly* sure. The picture is constantly growing and now and then a change is made that upsets a part which had been considered finished for all time.

Here is a case in point. We have always been taught to think of a lubricant as a filler of rough surfaces. Oil fills up minute inequalities and interposes a film between two surfaces, so that for the friction between the surface there is substituted the internal friction or viscosity of the oil. Recent research, however, has thrown a doubt upon the infallibility of this theory. While a well lubricated journal or surface, in which there is an actual film of oil separating the two relatively moving surfaces, does behave according to the long established theory of lubrication, when we deal with partially lubricated surfaces, we encounter phenomena which are difficult to explain. The coefficient of friction between different metallic surfaces varies not only with different lubricants, but also with the same lubricant and different metals. This has led to careful study of just what constitutes "oiliness." The problem is being investigated in England by the Lubricants and Lubrication Inquiry Committee of the Department of Scientific and Industrial Research. A preliminary report of the work of the committee is found on another page.

As a result of this research the hint is thrown out that lubrication may be a *chemical* rather than a physical phenomenon. There is evidence to support the theory that there is an actual chemical compounding of the lubricating oils and the metals which they lubricate. The evidence is not complete, but enough has been brought forward to shake our confidence in the established theory of lubrication and to suggest that we may have to rearrange this portion of our puzzle picture.

The Einstein Theories

A Physical and Astronomical Review of Their Contents and the Evidence Pro and Con

By William H. Pickering, Ph.D.

Dr. William H. Pickering, of the Harvard College Observatory in Jamaica, one of America's best known astronomers, contributed two essays to the Einstein contest. Both of these impressed the Judges as being scientific critiques of the relativity hypotheses rather than popular explanations within the intent of the contest. It goes without saying, however, that both of them are interesting and authoritative; and we believe that both are in a style that will be entirely intelligible to our readers. In one of them Dr. Pickering writes as a physicist, in the other as an astronomer. In both he conveys the impression that while he recognizes the importance of the Einstein theories, and stands ready to give them every fair hearing and a willing acceptance if they turn out to demand this, he regards them as still unproven in full.

In submitting these essays for separate consideration Dr. Pickering necessarily had to duplicate between them a considerable amount of introductory statement and general material descriptive of the Einstein theories. In order that this duplication might be gracefully eliminated, we have worked the two essays together into one. Save for omitted matter, and for one or two brief connecting links which it was necessary to substitute for such matter, the text stands exactly as written by Dr. Pickering.
—Editor.

THE Theory of Relativity will be treated first from the physical side, leaving the three astronomical tests to which it has been put to be discussed later. There is one astronomical fact however that must be mentioned in this connection, and this is the discovery of the aberration of light by Bradley in 1726. It is found that every star in the heavens apparently describes a small annual ellipse, whose major axis is 41″ in length. This Bradley showed to be due to a combination of the velocity of the earth in its orbit, and the velocity of light; and it is so explained in all the elementary text-books on astronomy. It implies a stationary ether through which the earth is moving. The importance of this statement will appear presently.

The subject is usually illustrated by supposing a man to go out in a rainstorm carrying a vertical tube. If the rain is falling vertically, and the man stands still, the sides of the tube will not be wet, save by an occasional drop, but if the tube is moved, it must then be inclined forward in order to keep it dry. The angle of inclination, which corresponds to aberration, will depend on the relative velocity of the tube, corresponding to the earth, and the rain drops which correspond to the waves of light.

If three lines are dropped upon a point in space, each line being perpendicular to the plane containing the other two, we have what is known as a system of coordinates. Einstein's original theory of relativity, which he now designates as the "special theory," depends on two principles. The first is that "Every law of nature which holds good with respect to a coordinate system K must also hold good for any other system K′, provided that K and K′ are in uniform movement of translation." The second principle is that "Light in a vacuum has a definite and constant velocity, independent of the velocity of its source."

These two sentences may be considered as authoritative, being quoted in Einstein's own words.[1] The first of these principles need not greatly surprise us. The second is not well expressed, because it is ambiguous. He does not say how the first "velocity" is measured, whether relatively to the ether or relatively to the observer. In fact this is the very gist of the whole matter, as we shall presently see. In the case of sound the velocity is constant with regard to the medium, the air, in the case of light it is supposed to be constant with regard to the observer. It reaches him with a constant velocity, no matter how he moves.

In order to understand this statement clearly let us consider the appended tabular diagram. On a calm day imagine a source of sound at S in line *a*. This may be either a gun or a bell. Imagine an observer 1,100 feet distant, located at O. The velocity of sound in air is 1,100 feet per second. This velocity we will take as unity, as indicated in the third column, and the velocity with which the sound reaches the observer is also 1, as shown in the fourth. It will reach him in a unit interval of 1 second, as shown in the fifth. If the bell is struck, it will give its normal pitch or frequency, which we will also call unity, in the sixth column.

Now imagine case *b* where the observer is on a train advancing toward S. When he is 1,100 feet distant, the gun is fired, but as he is advancing toward it, he hears it at O in rather less than a second, as shown in the fifth column. The velocity of the sound with regard to him is rather more than unity, as shown in the fourth column. If the bell is sounded, the pitch, that is the frequency, is raised, because he receives more sound waves per second than before.

In case *c* the observer is stationary, but the source of sound is receding. At a distance of 1,100 feet the gun is fired, and the observer hears it after an interval of just one second, as in case *a*. The velocity with regard to the observer and through the medium are also unity. If the bell is struck the pitch is lowered, since he receives fewer sound waves per second, the reverse of case *b*.

Table I

Case	Source	Velocity in Medium	Velocity to Observer	Interval	Frequency	Observer
			Air			
a	S	1	1	1	1	O
b	S	1	1 +	1 —	1 +	O
c	S	1	1	1	1 —	O
d	S	1	1 +	1 —	1	O
			Ether			
A	S	1	1	1	1	O
B	S	1 —	1	1	1 +	O
C	S	1	1	1	1 —	O
D	S	1 —	1	1	1	O

In case *d* imagine the source and the observer 1,100 feet apart, and advancing on the same train. When the gun is fired, the velocity of the sound waves will be greater with regard to the observer, and he will hear the sound in less than a second, as in case *b*. When the bell is struck it will have the normal pitch, the same as in case *a*.

We find therefore that for sound the velocity with regard to the medium is always unity, while the velocity with regard to the observer, and the interval elapsed, depend only on the motion of the observer himself, and are independent of the motion of the source. The frequency of the vibrations, on the other hand, depends only on the relative motion of the

[1] *Journn. Brit. Astron. Asso.*, 1919, 30, 76.

observer and the source, but is independent of their common motion in any direction. Further, it makes no difference whether the source and the observer are moving on a train, or whether they are stationary, and a uniform wind is blowing past them.

In the case of light waves we shall find a very different state of affairs, although the rules for frequency are the same as they are for sound. In case *A* we have the normal conditions, where both the source and observers are stationary. In case *B* we have a representation of the Michelson-Morley experiment as supplemented by that of Majorana,[2] where the source is stationary and the observer advances. Unlike the case of sound, the interval elapsed, as shown by the experiment, is now the same as in case *A*, and since the distance to the observer is less, the velocity of light with respect to the ether must also be less than unity. Since the observer is advancing against the light, this will permit the velocity of light with regard to the observer to remain unity, in conformity with the second principle of relativity. Compare with case *b* for sound. As Jeans expresses it, "The velocity of light in all directions is the same, whatever the motion of the observer."[3] That is to say it appears to be the same to him, however he moves.

Case *C* represents Einstein's statement, as confirmed by Majorana's experiment. It does not differ from case *c* for sound. Case *D* is more complex, but accepting the statement above that the velocity is constant with regard to the observer, we see that the velocity through the medium must be less, and that the interval elapsed will be constant, as in case *B*. Could we use the brighter stars and planets as sources of light, several of these cases could be further tested.

This brings us at once to statements that contradict our common sense. For instance, Jeans says "no matter what the velocity of the observer is, the light surface, as observed by that observer, is invariably a sphere having that observer as center."[3] That is to say the light surface, or wave front, is a contracting, not an expanding, sphere. This, if confirmed, would go a long way toward making our universe a subjective rather than an objective phenomenon. Again imagine a flash of light, such as an explosion, to occur when an observer is in a given position. It makes no difference how the observer may move while the light is approaching him, whether several miles forward or backward, the light will reach him in exactly the same time, as is shown by Michelson's experiment. Or if two observers are at the same spot when the explosion occurs, and one moves forward, and the other backward, they will both see the explosion at exactly the same instant.

This sounds ridiculous, but not only is it what Jeans says, but it is the logical interpretation of Einstein's second principle, if Einstein means by velocity, velocity with regard to the observer. If he means velocity with regard to the medium, then the case is exactly the same as that of sound in air, and Michelson's experiment as well as the Maxwell-Lorentz theory of light is contradicted. This theory is now universally accepted, and Michelson's experiment has been carefully repeated by other observers, and fully confirmed. This is the very heart of the relativity question.

If we state the matter objectively it comes to this. The velocity of light with regard to the ether is a variable quantity, depending merely on where the observer chooses to go. As Eddington well says, "these relations to the ether have no effect on the phenomena and can be disregarded—a step which appears to divest the ether of the last remnants of substantiality."[4]

The only way of avoiding this apparent absurdity seems to be to consider that the ether moves with the earth. Michelson's result would then be fully explained. Of course this can only be true for a few miles above the earth's surface. Beyond that the ether must either be stationary or move with the sun. The velocity of light with regard to the ether would then be a constant, just as the velocity of sound is constant with regard to the air. This would contradict Einstein's second principle as it is generally understood. The trouble with this suggestion is that it fails to account for aberration, which, as already explained, appears to require that the earth should be moving through the ether. To meet this emergency would involve some modification of the undulatory theory of light, which apparently would not be impossible, but has not yet been made.

In 1915 Einstein brought out an extension of his first principle. This he calls the "general theory of relativity." It states that in our choice of coordinate systems we "should not be limited in any way so far as their state of motion is concerned."[1] This leads to the three astronomimcal consequences mentioned later in this paper, two of which have been more or less confirmed, and the third practically contradicted as fas as quantitative measures are concerned.[5]

As is well known the kinetic energy of a moving body may be expressed as $e = \frac{1}{2}mv^2$, but if the body is charged electrically, the fraction becomes $\frac{1}{2}\ (m + m^1)v^2$, where m' is a quantity dependent on the square of the electrical charge. That is to say, we have the normal mass of the body, and also what we may call its electrical mass. If when in this condition a portion of the mass is electrical, the question at once occurs to us, why may not the whole mass be electrical, in other words, a form of energy? Although this has not been satisfactorily proved hitherto, yet such is the general belief among physicists. As Einstein puts it "inert mass is nothing else than latent energy."[1] The same idea is sometimes expressed as "the mass of ordinary matter is due to the electromagnetic energy of its ultimate particles, and electromagnetic energy wherever found must possess mass, *i.e.*, *inertia*."[6] If that is so, since a ray of light on the undulatory theory is a form of electromagnetic energy, it too must possess mass. Since all mass with which we are familiar is subject to the attraction of gravitation, it seemed likely that a ray of light would be bent out of its course in passing near the sun, and this as we have seen was proved to be true at the recent solar eclipse.

That portion of the mass of a body due to its electrical charge can be readily shown experimentally to vary with the velocity of the body. Einstein has shown the same to be true of the normal mass, as is illustrated in the advance of the perihelion of the orbit of Mercury. He has also pointed out that gravitation, inertia, and centrifugal force are all closely related, and obey similar laws. Thus if we rise from the earth with accelerated velocity, we apparently increase our weight. Again if the velocity of rotation of the earth on its axis should be increased, our weight would be diminished. These facts are suggestive when we come to consider the ultimate cause of gravitation.

Another fact which must be rather startling to the older school of scientists is that momentum is no longer simply mv, mass times velocity, but that the velocity of light c, comes into the question, and the formula for momentum now assumes the form of

$$\frac{mv}{\sqrt{1 - \frac{v^2}{c_2}}}$$

For ordinary velocities this correction is extremely small, but it has been shown to be necessary, both theoretically and experimentally, when dealing with the higher velocities with which we are now familiar.

The theory of relativity is so widespread in its application that several other theories have become more or less intimately combined with it, for which Einstein is in no way responsible. One of these is known as the Fitzgerald-Lorentz theory, that all bodies are subject to a contraction in the di-

[2] *Comptes Rendus*, 165, 424, and 167, 71.
[3] *Monthly Notices R. A. S.*, 1919, 80, 104.
[4] *Monthly Notices R. A. S.*, 1917, 77, 379.
[5] *Astro-Physical Journal*, 1917, 46, 249. *Journ. Brit. Astro. Asso.*, 1920, 30, 276.
[6] *Monthly Notices, R. A. S.*, 1917, 77, 377.

rection of their motions through space. This was first suggested in order to explain the Michelson-Morley experiment, but has proved inadequate to do so, particularly when the observer is receding from the source. This contraction is expressed by the same factor used in the denominator of the revised expression for momentum, given above. Again the quantity c is so enormous, that even for large bodies at planetary velocities the contraction amounts to very little. Thus the earth moving at a speed of eighteen miles per second in its orbit, is flattened only 1/200,000,000, or 2.5 inches. On the other hand for high velocities of many thousand miles per second, such as we have become familiar with in the case of the radio-active substances, the flattening is a very considerable fraction of the diameter of the moving body, one-half or more, and in the case of the corpuscles of light, if that theory were adopted, this flattening becomes equal to the diameter, and their thickness is reduced to zero.

When we view Einstein's theories from the astronomical standpoint, the earliest fact bearing on relativity that we need consider was the discovery of aberration, by Bradley, in 1726, as seen above. In 1872 Airy observed the star γ Draconis through a telescope filled with water. Since the velocity of light is less in water than in air, we should naturally expect to find the aberration appreciably increased. It was found, on the other hand, however, to be unaffected.

In 1887 the results of the famous Michelson-Morley experiment were published.[7] In this experiment the velocity of light was measured in various directions with regard to the motion of the earth in its orbit. If the ether were stationary, and the earth moving through it, different velocities should be obtained in different directions. Such was not the case however, and the experiment indicated that the ether moved with the earth. It thus flatly contradicted the conclusions founded on aberration.

Einstein's Special Theory of Relativity, of 1905, as we have seen, resolves this contradiction. But as we shall presently see, it is the General Theory, of 1915, that leads to astronomical applications of broad scope. It indicates, for instance, that there is no essential difference between gravitation and inertia. This idea may be crudely illustrated by our feelings of increased weight when an elevator starts rapidly upward. A man while falling freely in space ceases to feel the pull of gravitation.

But we must not as yet conceive of the theory of relativity as a universally accepted and unquestioned truth of science. Eddington is its leading English exponent, and he is supported by such men as Jeans, Larmor, and Jeffreys. On the other hand, the theory has been severely criticised by Lodge, Fowler, Silberstein, and Sampson. Few American scientists have expressed any opinions in print on the subject, and the recent eclipse observations, to which we shall refer later, are to be repeated with more suitable instruments for verification in 1922, in the hope of obtaining more accurate and accordant results.[8]

An appurtenance of the Einstein theories which bears much the same relation to it as does the Lorentz-Fitzgerald contraction, mentioned above, is the idea, first clearly stated by Minkowski, that time is a kind of space—a fourth dimension. This the reader will doubtless find to be the most difficult portion of the theory to picture in his own mind. It is entirely unsupported by experiment or observation, necessarily so, and is based wholly on mathematical and philosophical conceptions. Our distinction between space and time seems to be that the direction in which we progress without effort is time; the other directions, in which we have to make an exertion to move ourselves, or in which we are carried, are space. How many dimensions empty space may have, we really have no means of knowing, because we can neither see nor feel it. Matter we know has three, length, breadth, and thickness, also that it lies remote from us in three corresponding directions. These facts may have given us the erroneous impression that space too had only three dimensions. Now it is claimed that time is a fourth, and that there are also others.

In order to illustrate this, Eddington asks us to imagine a movie film taken of a man or of any other moving object. Let the separate pictures be cut apart and piled on one another. This would form a sort of pictorial history of the individual for a brief interval in his life, in the form of a cube. If we attempt to pick it up, it falls apart, thus clearly showing the difference between time and space. But suppose it now all glued together in one solid cube, so that it is no easier to cut a section in one direction than in another. That is Minkowski's idea of space and time, and further, that the direction in which we should cut it depends merely on the velocity with which we are moving through space. I should cut it parallel to the films, but a man on a rapidly moving star, in order to separate it into space and time, would cut it in an inclined direction. That is a thing which may be true, but it is one which we believe no mortal man can clearly picture to himself.

On the other hand Turner has recently made a very interestin point,[9] namely, that the fourth dimension as actually treated by the mathematicians is not time itself, but time multiplied by a constant—the velocity of light.[10] Without affecting the astronomical proofs of relativity at all, this simplifies our conceptions enormously. In ordinary every-day life time and space cannot be identical, any more than a yard can be identical with a quart. On what is known to physicists as the centimeter gram-second system, distance is represented by l, mass by m, and time by t. Velocity is then distance divided by time, $\frac{l}{t}$, or as we say in English units, so many feet per second, and the fourth dimension may be expressed as time multiplied by velocity, $t \times \frac{l}{t} = l$. That is to say, it is simply distance, just like the other three dimensions. To say that time is the fourth dimension from this point of view, appears to us just as ridiculous as it would be to attempt to measure the velocity of a train in quarts. It is quite correct, however, although unusual, to speak of a given train as moving at a speed of 10 quarts per square inch per second, $\frac{l^3}{l^2 t} = \frac{l}{t}$. This would be equivalent to a velocity of 33 miles per hour.

If I wish to give a complete dimensional description of myself in my four dimensions, I must give my length, my breadth, and my thickness, ever since I came into being, and also the course I have traversed through space since that time. This latter distance will be expressed in terms of a unit whose length is 186,000 miles, the distance traversed by light in one second. The distance which I travel through space annually is enormous, and very complex as to direction. It involves not merely my own motions as I cross the room, or take a train or steamer, but also those due to the rotation of the earth on its axis, its revolution round the sun, and the motion of the latter through the heavens. In general I travel, or in other words increase my length in the fourth dimension, by over 4,000 units a year. The fourth dimension accordingly, if this view is accepted, is simply a distance like the other three, and perfectly easy to understand.

We now come to the three actual tests by which the theory has been tried. The planets as is well known revolve about the sun in ellipses, with the sun in one of the foci. That is to say, the sun is not in the center, but a little to one side of it. The end of the ellipse where the planet comes nearest to the sun is called the perihelion, and here the planet is moving most rapidly. The other end is called the aphelion, and here the motion is slowest. According to Newton's theory of gravitation, if a spherical sun possesses a single planet or

[7] *Amer. Journ. Sci.*, 34, 333.

[8] *Monthly Notices, R. A. S.*, 1920, 80, 628.

[9] *The Observatory*, 1920, April. From an Oxford Note Book.

[10] *Monthly Notices, R. A. S.*, 1917, 78, 3 *De Sitter*, 1919, 80, 121, Jeans, 80, 145 Jeffreys.

companion, its orbit will be permanently fixed in space unless perturbed by some other body. If a second planet exists, it will cause the perihelion of the first slowly to advance. According to Einstein the mass of a planet depends in part on its velocity. It will therefore be less at aphelion where it is moving slowly than at perihelion where it is moving rapidly, consequently in addition to the Newtonian attraction we have another one which increases as we approach the sun. The effect of this will be to cause the perihelion of the orbit to advance, whether there is a second planet or not.

Among the larger planets Mercury has the most eccentric orbit, and it also moves most rapidly, so that it is particularly well adapted to test the relativity theory. The observed advance of its perihelion is 574″ per century, instead of the theoretical figure 532″, due to the other planets—a difference of 42″.[11] This has long been a puzzling discrepancy between observation and the law of gravitation. Prior to Einstein, attempts were made to eliminate it by assuming a certain oblateness of the solar disk. If the equatorial diameter exceeded the polar by only 0″.5 the whole advance would be accounted for, but not only has this ellipticity failed of detection, but if it existed, it should produce a very noticeable and inadmissible change in the inclination of Mercury's orbit, amounting to about 3″ per century, as has been demonstrated by both Herzer and Newcomb.[12]

Einstein from computations alone, without introducing any new constants or hypotheses whatever, showed, if the theory of relativity be accepted, that the sun should produce an acceleration of 43″ per century, thus entirely accounting for the observed discrepancy, far within the limits of accuracy of the observations. The only other planet whose orbit has a large eccentricity, and that is suitable for investigation, is the planet Mars. Here the discrepancy between observation and theory is very slight, only 4″, and a portion of that may be due to the attraction of the asteroids. This deviation is so slight that it may well be due entirely to accidental errors of observation, but however that may be, Einstein's theory reduces it to 2″.7.

This all seems very satisfactory and complete, but the trouble with it is that the coincidence for Mercury is rather too good. It is based on the assumption that the sun is a perfect sphere, and that the density of its surface is uniform from the equator to the poles. This would doubtless be true if the sun did not revolve on its axis. In point of fact it does revolve, in a period in general of about 26 days. Consequently an object on its equator must experience a certain amount of centrifugal force. Therefore if its surface were of uniform density the sun would be an oblate spheroid.

It can be readily shown that the theoretical excess of the equatorial over the polar diameter, due to the centrifugal force, should amount to only 0″.04, an amount which could hardly be detected by observation, and might readily be concealed by a slight excess of equatorial over polar density. Any reasonable excess of density at the center would diminish this result but slightly. The molecular weight of the central material is probably about 2.[13] This computed equatorial excess is one-twelfth of the amount necessary to cause the observed advance, and should therefore cause an advance of the perihelion of about 3″.5 per century, reducing the difference between the observed advance, and that caused by gravitation to 38″.5. According to Einstein the advance due to relativity should be, as we have seen, 43″, a discrepancy of 4″.5 per century, or 10 per cent. Jeffreys has remarked that any discrepancy such as 10″ "would be fatal to a theory such as Einstein's, which contains no arbitrary constituent capable of adjustment to suit empirical facts.[14] It must be pointed out here however, that so far as known, this small correction to the motion of Mercury's perihelion has not previously been suggested, so that there has been no opportunity hitherto for its criticism by others.

It was due largely to the success with Mercury that it was decided to put the relativity theory to another test. According to the Newtonian theory, as stated by Newon himself, corpuscles as well as planets have mass, and must therefore be attracted by the sun. According to Einstein, owing to their high velocity, this attraction must be twice as great as it would be according to the theory of gravitation. If the ray of light proceeding from a star were to pass nearly tangent to the sun's limb it should be deflected 0″.87 according to Newton. According to the theory of relativity it should be deflected 1″.75. Stars of course cannot usually be observed near the sun. It is therefore necessary to take advantage of a total solar eclipse, when the sun is completely hidden by the moon.

Two expeditions, one to Africa, and one to South America, observed successfully the total eclipse of May 29, 1919. The former was located on the island of Principe in the Gulf of Guinea. The latter was located at Sobral, Brazil. Their equipment and results are shown in the following table, where the successive columns give the location, the aperture in inches of the telescopes employed, their focus in feet, the number of plates secured, the number of stars measured, their mean deduced deflection from their true positions by the attraction of the sun, and the deviations from the theoretical results.[15] In the first and last line of the table as here presented this deviation is taken from Einstein's computed value of 1″.75. In the second line the difference shown is from the value required by the Newtonian theory 0″.87. The results obtained with this telescope were rejected however, although they were much the most numerous, because it was found that for some reason, supposed to be the heating of the mirror by the sun before the eclipse, the star images were slightly out of focus, and were therefore considered unreliable. The results with the two other telescopes were not very accordant, but the 4-inch had the longer focus, secured the greater number of plates, and showed the greater number of stars. The results obtained with it therefore appear to have been the more reliable. They differ from Einstein's prediction by 13 per cent.

Table II

Location	Aperture	Focus	Plates	Stars	Defl.	Dev.
Principe	13	11	2	5	1″.60	−0″.15
Sobral	13	11	19	12	0 .93	(+0 .06)
"	4	19	8	7	1 .98	+0 .23

We now come to the final test which has been applied to Einstein's theory. Einstein showed that in the intense gravitational field of the sun, the theory of relativity required that all of the spectrum lines should be shifted slightly toward the red end. The shift however is exceedingly small, and can only be detected and measured with the most powerful modern instruments. Moreover only certain lines can be used, because owing to varying pressure in the solar atmosphere, which affects many lines, as well as to rapid motion in the line of sight, which may affect all of them, still larger displacements are liable to occur.

According to the theory of relativity the displacement of the lines should be + 0.0080 A. St. John at Mt. Wilson found a displacement for the cyanogen lines of only + 0.0018 A.[16] Evershed at Kodaikanal found + 0.0060 at the north pole of the sun, and + 0.0080 at the south pole. These latter values however were only for the stronger lines. The weaker lines give much smaller shifts, as do those of calcium and magnesium.[17] According to Einstein all lines should give nearly the same shift, an amount proportional to the wave length. It therefore appears that we must conclude by saying that Einstein's theory of relativity has been partially, but not completely, verified.

[11] "Gravitation and the Principle of Relativity," Eddington. Royal Institution of Great Britain, 1918.

[12] *Journ. Brit. Astron. Assoc.*, 1920, 30, 125.

[13] "The Interior of a Star," Eddington. *Scientia*, 1918, 23, 15.

[14] *Monthly Notices, R. A. S.*, 1919, 80, 138.

[15] *Monthly Notices, R. A. S.*, 1920, 80, 415. *Journ. Brit. Astron. Asso.*, 1919, 30, 46.

[16] *Astro-Physical Journ*, 1917, 46, 249.

[17] *Journ. Brit. Astron. Assoc.*, 1920, 30, 276.

Cloud Photography*

Construction of Apparatus and Methods of Procedure

By Arthur J. Weed

THE first requisite in cloud photography is a good camera for that special purpose. Not necessarily an expensive apparatus, but one that is rigid and has the necessary means of attachment to a firm support.

A suitable ray filter, or black mirror, is necessary to cut out the actinic light of the blue sky and render, in the finished print, white clouds on a dark background just as we see them on a darker background of blue.

Excellent pictures may be made of certain types of clouds with a light bellows camera, when it is sheltered from the wind, but if one wishes to do really good work this will be found too light and shaky for the purpose, as some of our most interesting clouds occur only when a strong wind is blowing.

In order to get an unobstructed view, means should be provided for mounting the camera on the highest possible elevation like the top of a hill or the roof of a building.

Fig. 1 shows a camera built by the writer at Mount Weather Observatory. Two permanent mountings were required for a full sweep of the horizon, each of which consisted of a piece of yellow pine timber 3 by 4 inches, the upper end turned to a diameter of about 3 inches. These turned portions of the posts were shellacked and when not in use were protected by metal covers made from pieces of tubing with a head soldered into one end. The method of attaching the post to the metal railing is shown in the photograph.

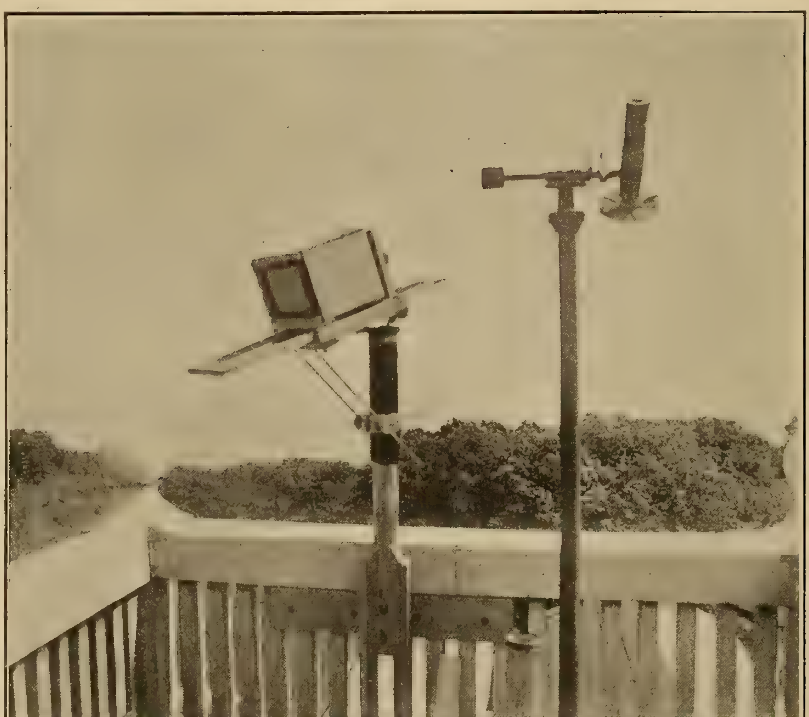


FIG. 1. CLOUD CAMERA (ON LEFT) USED AT MOUNT WEATHER AND PICKERING POLARIMETER (ON RIGHT)

The holder for the camera consisted of a tube to fit over the turned wood post, a frame to hold the bed of the camera, and two braces by which the vertical adjustments were made. The tube was a piece of conduit pipe used to protect underground electric wires. To the top of the tube was secured a crosspiece of wood, and to this was hinged one end of the frame carrying the camera bed. To the other end of the frame two round metal braces were attached by hinges. The tube was sawed open from the bottom for about one-half its length and a U-shaped strap of brass was placed around it. Through the free ends of this brass strap a bolt was inserted on which were two pairs of thick washers, each pair grooved to hold one of the metal braces of the frame. The bolt was provided with a large milled head nut. When this nut was tightened the camera was firmly secured both vertically and horizontally. The frame was constructed so that the bed of the camera slid in between the two side rails where it was secured in position by four large-headed brass bolts provided with milled head nuts. The heads of these bolts gripped the edge of the camera bed. This frame could be swung around on the post and had a vertical movement of 90°.

The camera consisted of a bed or frame, made from a piece of maple flooring, on which were mounted two wooden boxes painted a dead black on the inside and constructed of the proper size to telescope together readily. The outer box was screwed to the camera bed and the front end of the inner box was secured to a maple frame having an L-shaped extension which was fitted to slide on the maple bed. This frame carried the lens board. The arbitrary sizes to be followed in constructing such a camera are that the combined length of the two boxes plus the lap where they slide together shall equal the focal length of the lens it is desired to use. Also the outer box must conform to the size of the plate holder used so that a light trap can be arranged. In this particular camera a groove was made at the top and bottom of the rear end of the outer box a little wider than the thickness of the plate holder, and a flat spring was fastened in the outer edge of each groove which forced the plate holder against the end of the camera box. The ground-glass focusing screen was mounted in a frame corresponding in size to the plate holder and had to be removed before inserting the holder. When only one lens is to be used with such a camera the two boxes can be adjusted to get the proper focus of a distant object on the ground glass and then firmly secured to the bed at that point. The only use for the focusing screen thereafter is to see just how much of the view will appear in the picture.

For quick work a special view finder was made and attached to the camera. This was in two parts, as shown in Fig. 2. A rectangular frame proportional to the size of the plate to be used was mounted on the top of the camera box and had both a vertical and a horizontal wire stretched across it, meeting at the center. This frame was mounted so that it could be folded down upon the top of the camera and was retained in either position by a bent flat spring, the free ends of which pressed against the bottom or side of the frame. Behind the frame, extending lengthwise of the camera, was a round rod mounted on supports at each end and having the underside flattened. Sliding on this rod was a vertical post with a small ring at the top to sight through. The center of this ring was level with the cross wires in the frame. A

*From *The Monthly Weather Review,* August, 1920.

spring attached to the lower end of the post and pressing up against the flattened portion of the rod held the post vertical. When not in use this post could be turned down on either side of the rod and out of the way.

The frame was in exact proportion to a 6½ by 8½ plate, that being the size of plate holder used with this camera. The vertical post was adjusted to such a position on the rod that when one sighted through the ring all that was visible inside the frame would also be shown on the ground glass of the camera. This position was then marked on the top of the camera. The dimensions of a 5 by 7 and a 4 by 5 plate were marked in pencil on the ground glass of the camera. The vertical post of the finder was then adjusted to show both these views approximately, and the corresponding positions of the post were marked on the camera. This allowed the use of small plates in the 6½ by 8½ holders by using "kits," and the camera could be quickly sighted on a changing cloud, the finder showing just what would be included in the picture.

Fig. 1 shows the camera as at first constructed, but considerable difficulty was experienced in using a focusing cloth on windy days. Another box was therefore constructed of light material corresponding in width and height to the outer box of the. camera This was of sufficient length to occupy the rear projection of the camera bed and proved to be a valuable acquisition, as, in addition to forming a focusing hood, it also supplied a location for the plate holders. A line drawing of the completed camera is shown in Fig. 3.

The back of this box was left open, except for two small pieces of thin wood set across the two lower corners. These retained the plate holders when the front of the camera was elevated to sight on a high cloud.

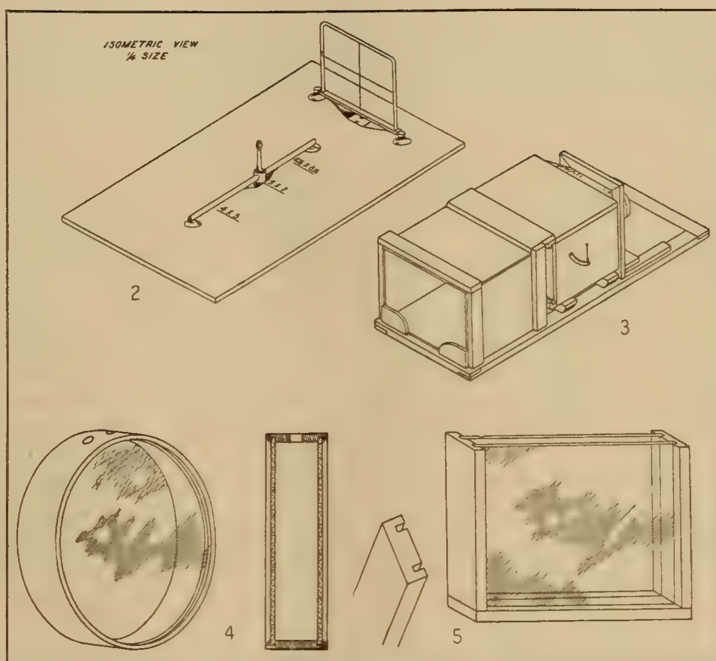
On this side of the camera box was placed an inclinometer. This consisted of a short piece of fine brass wire having a loop bent in the upper end and a flat-pointed weight soldered to the lower end. A small brass screw was inserted through the loop and then screwed into the side of the camera box. The wire could swing free on the screw and the weight hang vertical. The camera was then leveled and a brass sector, graduated from 0° to 90°, was placed in position, so that as the camera was tilted upward the angle from the horizon to which it was elevated would be indicated by the pointed end of the hanging weight. This should be boxed in and have a cover of glass or celluloid, otherwise it must be sheltered from the wind while the angle is being read.

In this branch of photography, as in all others, a good lens is to be desired. The lens used for most of the cloud pictures shown with this article was a Goerz 10½-inch Double Anastigmat, F.7.7, the property of Prof. A. J. Henry, who was then the Official in Charge at Mount Weather.

Occasionally a creditable cloud picture may be made with the lens alone. This applies particularly to the gray clouds. But for white clouds in a blue sky either a ray filter or black mirror must be used.

When the camera is pointed at the sky we see on the ground glass the white clouds on a darker background of blue sky; but when these same rays of light are allowed to fall on the ordinary sensitized plate the blue and violet rays from the sky are so much more actinic than the light rays reflected from the clouds that when the cloud has been properly exposed the sky is overexposed and, in consequence, the contrast between the blue and white is entirely lost, and the finished print shows only a bare patch of white for the sky. If, however, a ray filter of the proper color is placed on the front of the lens, these intensely actinic rays of blue and violet are filtered out and the resulting print shows a white cloud on a dark background. In practice the filter should be only sufficiently deep in color to give the required contrast without unnecessarily increasing the length of the exposure.

The first filters used on this camera were cells filled with colored liquid. These were made by using a fairly thick piece of brass tubing. A ring about ½ inch long was cut from the tube and either end bored out to form a recess for the glass plates as shown in Fig. 4. Two holes were drilled in this ring and each tapped for a screw plug. These holes were for filling and cleaning the filter. A deposit will sometimes form on the inside surface of the glass plates which it is necessary to remove with a small tuft of cotton, held in a twisted loop of fine wire. If the filter is cleaned often enough a stream of water driven into one hole and escaping from the other will be sufficient to remove all deposits from the glass. The two holes are placed as close together as possible, and in filling the cell one acts as a vent when the solution is introduced through the other. The glass sides were made from lantern slide covers, which were selected so that there should be no spots or flaws in front of the lens. To cut the glass to the required size one was placed on a sheet of paper on which was drawn a circle the size of the recess in the brass ring. A glass cutter was used to square the lantern slide cover to the same dimensions as the diameter of the circle. Leaving the plate on the circle the corners can be cut off so that the plate is an octagon and if the cutter is in good condition the eight corners can be trimmed off leaving the glass nearly round. The remainder of the fitting may be done with a sharp file wet with a solution of camphor dissolved in turpentine or the glass may be ground on a stone with water as a lubricant. In either case some care is required to prevent scratching the surface of the glass. When the glasses have been fitted and cleaned they are placed in position and cemented with thick shellac. As soon as this hardens the cell is ready for use.



FIGS. 2-5. CONSTRUCTIONAL DETAILS

2, View finder; 3, cloud camera complete; 4, details of ray filter cell; 5, tank for dyeing ray filters.

Potassium bichromate dissolved in water, and afterward filtered makes an excellent solution for summer use. Distilled water should be used if possible, and the ingredients carefully measured so that in refilling the cell the same density of color will be obtained as in the original solution, and, in consequence, the same length of exposure required. The best method is to make up enough of the solution for several fillings and filter it into a bottle for future use. To prevent evaporation the cork should be dipped in melted paraffin before inserting in the bottle.

Where one wishes to obtain winter cloud pictures there is the danger that this type of filter may freeze. For this

reason as stated gelatin filter is best. Such a filter may be purchased from the larger supply houses or can be made up from a dry plate.

To construct a stained gelatin filter place an undeveloped dry plate, or lantern slide plate, in the hypo bath until the silver is all dissolved and the plate becomes clear. Wash out the hypo as with a regular fixed plate and it is ready for staining. If the plate is allowed to dry after washing it should be soaked up again just before staining. For a yellow stain a few grains of picric acid dissolved in water may be used, but as this acid is rated as an explosive it is sometimes difficult to procure. Ammonium picrate may be substituted, or a good aniline dye may be used.

FIG. 6. DISTANT LIGHTNING ON "POLYCHROME" PLATE

For dyeing gelatin filters the writer uses a deep but narrow tank so that the plate will stand vertically, or nearly so. The sides of the tank were made from two 4 x 5 dry plates from which the gelatin films had been removed. The two ends and bottom were made from strips of hard rubber with two grooves milled in them into which the glass plates were cemented as shown in Fig. 5.

The dye should be prepared and filtered to remove all particles which might settle on the soft gelatin surface and cause opaque spots. Place the plate in the tank so that it tilts over to one side and the dye can be poured upon the glass side and not directly upon the gelatin film as it would make too deep a color at one spot. The film will take the color very quickly and should be removed from the tank immediately, rinsed and set up to dry.

In some instances it is desirable to show the landscape with the clouds. This requires a ray filter in which the color shades from a clear glass to the depth necessary for a cloud well up in the sky. This tank will be found well adapted for the making of such a filter. Place sufficient dye in the tank to stand at a height of about ¾ inch. Lower the prepared plate into the dye and immediately run water into the tank until it overflows and the water runs away clear. On removing the plate it will be found that because of the gradual dilution of the dye in the tank the gelatin film will be shaded from a deep color at the bottom of the plate to clear glass at the top.

When the plate has been dried a section can be selected from which to cut the filter to suit the requirements.

FIG. 7. PRINT FROM TEST PLATE FOR TIMING RAY FILTERS

The finished filter may be left in a square or rectangular shape or cut round in the same manner as previously described for the filter cell. Whatever the shape decided upon, a cover glass the same size and shape should be cut and the two cemented together with Canada balsam. This protects the gelatin film from injury.

Provision must be made for holding the filter in front of the lens—either something to slip over the lens hood or an independent mounting attached to the camera front. Whatever the means employed it is important that the back of the filter be shaded from the sun so that no reflected light can enter the lens.

On completion of a filter it is necessary to time it for the proper exposure, which can be accomplished by the sacrifice of one plate. From an exposure meter get the normal time of exposure required for the stop which it is desired to use, time of day, etc. Draw the plate holder slide a short distance and make an exposure corresponding to the above data. Draw the slide a little farther and make the same exposure. Continue this until the slide is entirely withdrawn. When this plate is developed its density will be divided into strips, or sections, corresponding to the withdrawals of the plate holder slide. The last section exposed will have had *one* normal exposure and will be underexposed, for the filter will have cut down the amount of light which entered the lens. The previous section will have had *two* normal exposures and, in consequence, will show increased density and strength. The next section will give the result of *three* normal exposures, the next one *four*, etc.

Suppose the third section of the negative is found to have the required printing qualities—the filter should be marked "3T," meaning "3 times," and whenever this particular filter is used it is only necessary to multiply the normal exposure given by the exposure meter three times to give the time of exposure necessary to produce the desired density of negative. Fig. 7 shows a print from such a test negative.

For photographing the minute details of high cirrus clouds a black mirror is superior to a ray filter. The mirror must be mounted in such a manner that its reflecting surface stands at an angle of 33° with the axis of the lens. In this

FIG. 8. THUNDERSTORM IN SHENANDOAH VALLEY. DISTANT :5 MILES

position the rays of light which come from the blue of the sky are partially polarized and are not reflected by the mirror, while the white light from the clouds is reflected very clearly. The mirror must be a black, or very dark, glass, as an ordinary piece of clear glass blackened on the back with pigments while seeming perfect to the eye will, in nearly all cases, give a double image through the lens, one reflection from the front surface of the glass and a second reflection from the back take place. This gives the cloud a blurred outline on the negative.

In a recent publication, the name of which the writer cannot recall, it was stated that if the back surface of a piece of clear glass were roughened or ground coarse before painting it black, this double reflection would be eliminated. This is passed along as an experiment worth trying, for a good black mirror is expensive.

One objection to the use of a mirror in cloud photography is that the reflection reverses the sky in the finished print. At Mount Weather another camera was constructed on a more elaborate scale for cloud work than the one here described. This was fitted with a real black-glass mirror and means were devised for obviating the reversal of the sky, but there was no opportunity to try it out before the closing of that observatory.

The plates used for most of the pictures made at Mount Weather were "Standard Orthonon." These were found to give excellent results on white clouds but for clouds lighted up in color at sunrise and sunset "Standard Polychrome" plates were to be preferred. This latter plate was found to be well adapted for lighting pictures, being sensitive to red and yellow.

One night two "Orthonon" plates were exposed in succession on a receding storm. The third and last plate exposed was a "Polychrome," and as the storm was at that time several miles distant the lens was allowed to remain open until the lightning ceased. When developed the two "Orthonon" plates showed nothing, while on the "Polychrome" every flash was seen. This picture is reproduced in Fig. 6. In the original the

FIG. 9. SAME AS FIG. 8, TEN MINUTES LATER

contour of Bull Run Mountains can be seen, behind which the lightning was descending. This range of mountains is 20 miles distant from Mount Weather.

A rubber stamp was used for imprinting data slips similar to the following:

	Name	
No. .		
Date	Time	
Direction	Angle	Filter
Lens	Stop	Exp.
Plate	Dev.	Formula
Print	Time	Dist.

As the plate holders were loaded in the dark room one of these slips of paper was marked with the number corresponding to that on the plate holder and the name of the plate therein. One slip was used for each plate. When the loaded plate holders were placed in the receptacle at the back of the camera these slips were inserted under a spring clip just above them.

After exposing a plate in the camera its slip was filled out with the name of the cloud, date, time of day, direction by compass, angle in degrees from the horizon, as shown by the inclinometer, ray filter used, lens, stop and length of exposure. These data slips were taken to the dark room with the plate holders, and after development the plates were filed away in negative envelopes as preservers, imprinted by the same rubber stamp with the above data filled in, together with the name of the developer and its formula number. The envelope was marked with the serial number of the negative, which number was also scratched in the upper corner of the film to prevent its being misplaced in printing. When prints were made, the paper used, time of printing, and distance from the light were added under their proper heading. This data adds very materially to the value of one's negatives.

As to a developer, every one has his favorite formula. Some workers claim that the long feathery lines of the cirrus are only properly brought out with hydrochinone, but if the exposure is correct there is little choice in developing agents.

Giving the right exposure means having a fast lens, and a filter only sufficiently colored to cut out the blue and adding as little as possible to the time. This is particularly necessary on a fast-moving cloud having fine detail on its edges.

Since this cloud work was done at Mount Weather the Bureau of Standards has conducted a series of experiments on plates and filters for this class of work. They state that the best plate for sensitivity in red is the "Ilford Panchromatic" and a good plate for the same is the "Cramer Spectrum Process." For a commercial ray filter they recommend "Wratten's Minus Blue," or "Kramer Isochromatic, medium-rapid, double coated minus blue."

In preparing this article it has been the aim to deal more with the how and why of cloud photography than the treatment of the subject from a meteorological standpoint. The apparatus described was made up of cheap material which could be acquired in an isolated location, yet it worked very successfully. It is not expected that the directions and suggestions here given will be followed implicitly, but that each worker will, as in this case, adapt means to ends.

In this work there is a psychological moment in which to "get your cloud" (compare Figs. 8 and 9), but, unfortunately, the game has to be played under the rules of "catch-as-catch-can." It therefore behooves the worker to be always ready. The cloud camera at Mount Weather was located just under the rafters beside the stairway to the roof, with plate holders loaded, yet many a hurried trip was made from the main floor to the roof only to find that the opportunity for a successful picture had passed.

Aside from its meteorological value the work has all the fascination of hunting big game without its attendant danger, and there is no "closed season." You will learn what to hunt for in April; what in October.

A cumulus cloud is easy to get, but how many really good photos have you seen of change cirrus, mammatocumulus, or scarf cloud? These are a few samples of the big game which it pays to go after, and to be able to exhibit a good specimen picture of such a cloud will be found as satisfactory as the showing of a pair of antlers.

DEGREE OF TEMPERATURE TO WHICH SOILS CAN BE COOLED WITHOUT FREEZING

By George Buoyoucos

The general impression seems to be that when the temperature of soils falls slightly below the freezing point (0° C. or 32° F.) they freeze, that is, the soil moisture is converted into ice. This is hardly the case, however. In conducting investigations to study and measure the different forms of water in the soil by means of the dilatometer method and to study and measure the concentration of the soil solution directly in the soil by means of the freezing-point method, it was discovered that it is almost impossible to freeze the soils when they are cooled only slightly below the freezing point. This is true even when the concentration of the soil solution is exceedingly small and the freezing-point depression consequently negligible. Indeed, it was found that it is difficult to start solidification in the soils unless they are supercooled at about 1° C. below their true freezing point. Even at this degree of undercooling freezing begins only with vigorous agitation. If the soil is not vigorously agitated or disturbed it will remain at this temperature indefinitely without freezing. As the degree of undercooling is increased, however, the ease with which solidification is induced is also increased. Finally a temperature is reached where freezing starts automatically without agitation of the soil mass. This critical temperature is surprisingly low for all soils being about —4.2° C. (7.56° F.) for the mineral soils (sand, loam and clay), and about —5° C. (9° F.) for the peats and mucks. The maximum supercooling is still greater for water and for artificial materials, silica, carbon black, gelatin and agar amounting in all cases to about —6° C. (10.8° F.). Since water freezes at about the same degree of supercooling as the artificial materials, it would logically seem that it is the water which limits the degree of supercooling of those materials and that they themselves have no inflence on the degree of supercooling of water in one way or the other.

The question now rises, why do the soils withstand a smaller degree of supercooling than the artificial materials?

No definite explanation can be offered for this phenomenon. It would appear, however, that the true explanation is to be found in the difference in the size of particles of the two classes of materials.

In order to ascertain if the degree of moisture content exerts any influence upon the resistance of soils to freezing, different water contents were employed in all the various soils. The results failed to show, however, that moisture had any appreciable influence on the resistance of soils to freezing.

The foregoing experimental results afford a new and significant insight into the temperature of soils during the cold seasons. The conclusion naturally follows that during mild winters and in mild climates in the winter the soils may not freeze even though they are cooled below their freezing point.

In the second place these findings prove quite conclusively that the method now in vogue for measuring temperature in soils in cold seasons may not give entirely the true facts. The thermometers will be recording the temperature to be several degrees below the freezing point and yet the soils may not be actually frozen.

The foregoing experimental results are very significant from still another standpoint. As it is well known, water in the liquid state has twice the specific heat that ice has. As long as the soil moisture remains in the liquid state the temperature fluctuations in the soil will be correspondingly slower and smaller.—Abstracted from the *Journal* of Agricultural Research, Nov. 15, 1920, pp. 267-269.

Prehistoric Astronomy*

New Interpretation of Some Remarkable Rock Carvings in Scandinavia

By Dr. M. Schoemfeld

THE province of Bohuslän which was originally in Norway, but now belongs to Sweden, contains the most abundant collection of the Scandinavian engravings on rocks known in the language of the country as "*Helleristninger.*"

Those carvings thus far discovered were collected and reproduced by Baltzer, in his book entitled "*Glyphes des Rochersdu Bohuslän* (carvings on the rocks of Bohuslän) which was published at Götheborg in two series, which appeared respectively in 1881 and 1891.

Men of learning have long debated concerning these mysterious inscriptions seeking terms of comparison for them in the well-known legends of Nordic mythology, but the results of their discussions have been meager enough.

While examining Plate 49-50 of Series 1 in Balzer's works (Fig. 1) I was suddenly struck by the idea that it evidently contained a representation of the Great Bear and of the Milky Way in their exact relative positions. Upon making a search farther down beneath a crevice in the rock I was rewarded by finding a series of signs which recalled for the most part the classical signs of the Zodiac in their regular succession: Cancer the Crab, near Canis Minor, the little dog, Equuleus, the foal behind Pegasus and then Capricorn, the goat.

Since there seems to be no possible mistake about the matter, it only remained to interpret the figures situated between these two groups upon Baltzer's plate.

To begin with I observe two pairs of animals facing each other. Just Bing has compared these to the general type of the conventionalized pigeons found upon many Scandinavian monuments. But when we attempt to interpret the engraving in the sense of an astronomical chart we are obliged to reject this interpretation, and to identify these two pairs of animals respectively with the two hunting dogs, Canes Venatici and the two lions. While the two lower animals resemble dogs rather than lions, there is nothing to surprise us in this since the lion is an animal which is foreign to Scandinavia.

A third pair situated beneath and representing two human beings almost identical in form is readily identified with the heavenly twins Castor and Pollux. A third person who is turning his back upon the supposed figure of Pollux suggests the idea that it is meant to represent Auriga. A giant brandishing his hatchet and situated a little farther to the right may be meant for the giant Orion, while the two individuals to the left of Gemini may be Hercules and Boötes. The elongated animal to the right of the lions seems to be meant for the Lynx. A stag beneath Gemini may be meant for Draco and another lower down for the Monoceros; since these two animals are not found among the fauna of Scandinavia their transformation into stags would be only natural. Finally, the Cross placed above the Lynx probably corresponds to the *Mouche.* (*The author evidently refers to Musca—not the constellation in the southern hemisphere but a group north of Aries that formerly went by this name.*—Editor.)

Thus, according to this interpretation the constellations comprised between the Great Bear and the Zodiac are all represented in a succession which is partially irregular. If our interpretation appears to be debatable in certain points its general correctness is supported, nevertheless, by the fact that all of these astronomical figures are visible in the sky of the Bohuslän from September 23 to October 21 during the autumnal Equinox (Fig. 2).

Moreover, Baltzer's works contain other maps of the sky which are quite interesting. Fig. 3 represents Plates 3 and 4, No. 13 of Series II. In these we behold a long series of astronomical signs in perfectly correct order and without any accessory figures intermingled among them. In the middle is a really perfect representation of the Great Bear with the North Star directly above; to the right there follow in order the Lynx, Castor and Pollux, and Orion; to the left is Boötes the Herdsman; below are Cancer the Crab, and Leo the Lion, the latter extending along the image of a boat. If the reader

*Translated for the *Scientific American Monthly* from *La Nature* (Paris), for Feb. 5, 1921.

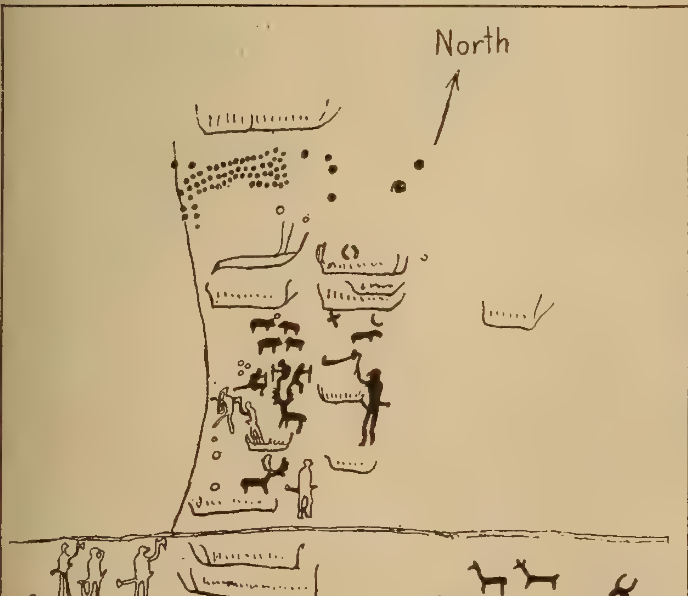


FIG. 1. ROCK CARVINGS AT BOHUSLÄN IN THE PARISH OF TANUM, AFTER BALTZER

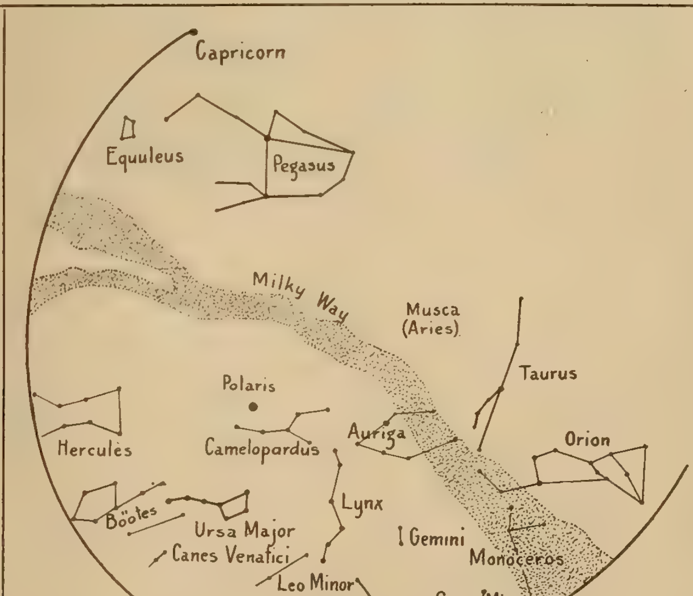
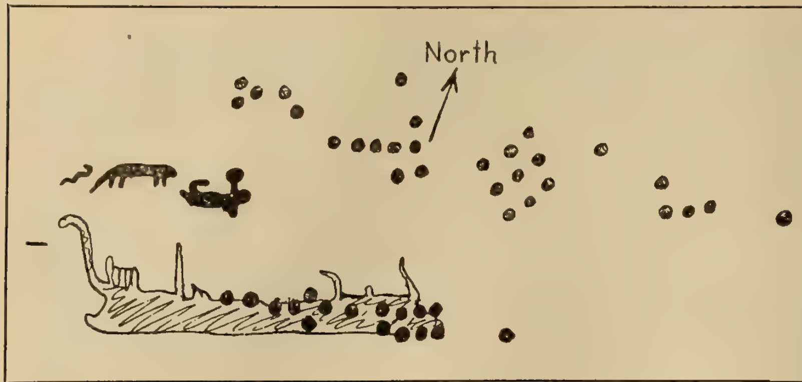
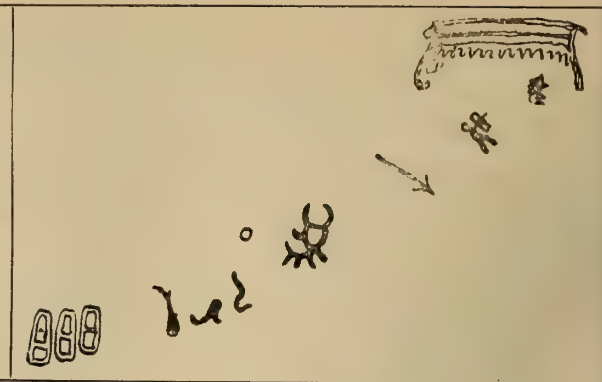


FIG. 2. CONSTELLATIONS VISIBLE IN THE SKY AT BOHUSLÄN FROM SEPTEMBER 23 TO OCTOBER 21





FIGS. 3 AND 4. ROCK CARVINGS AT BOHUSLÄN, AFTER BALTZER SERIES II, PLATES 3 AND 4 AND SERIES 1, PLATE 41

is still capable of feeling any doubt with regard to the correctness of our interpretation, he will surely be convinced that we are right if he will cast a glance at the three symbolic figures at the left of the engraving; the Serpent with its head turned to the left imitating almost exactly the position of the stars in this constellation: the two hounds, one of them standing and the other lying down (while the latter is less easily recognized his curling tail is unmistakable). This chart corresponds to the constellations visible in the sky from the 17th to the 21st of January; the choice among the signs is in large part identical with that of the picture previously examined, only the signs of the Zodiac being lacking.

A third map is found in Plate 41m of Baltzer's first series (Fig. 4). Here one may see the Fishes, the Dolphin, the Serpent, the Scorpion, the Archer, and the Fox (or possibly the Hound). The first four follow each other in correct order; the Archer and the Fox appear to be placed somewhat too far to the right, possibly in order to form a separate hunting scene. The constellations corresponding to these figures are found in the sky during the period from June 9th to July 11th. The presence of the Scorpion, an animal entirely unknown in Scandinavia appears to our mind a conclusive proof of the correctness of our interpretation of this symbolic design.

Plates 1 and 2, No. 6 of Series II, contain a man holding a horse surmounted by a group of dots in which it is easy to recognize the Auriga, the Charioteer, and Cassiopeia (Fig. 5). Plates 3 and 4, No. 15 of the same series probably represent the Milky Way, etc.

These engravings upon the rocks of Bohuslän have also enabled us to discover prehistoric celestial charts in Denmark.

The archaeologist, Henry Petersen, has described in his work entitled *Aarborger for nordisk Oldkyndighed* (Book of Art of Nordic Antiquities) which appeared in 1875, the astronomical symbols found in Denmark. His researches have proved that the images of the sun and the depressions in the form of a cup are found principally in North Zéeland, or more precisely in the region around Iselfjord. It is in this neighborhood, too, that the famous chariot of the sun of Trundholm and a large number of rock engravings representing the sun were found. This geographical distribution would seem to indicate a Scandinavian influence. Many of the carved rocks found in Denmark were discovered inside of megalithic tombs, and according to Henry Petersen they may have belonged to the Stone Age. Others, such as the two stones found at Ods Herred, bearing images of the sun and of boats probably belonged to the age of bronze, as do the Bohuslän carvings. We are of the opinion that we have discovered two celestial charts upon two stones found in megalithic tombs. These stones have no symbolic signs, like those of Tanum, but exhibit three series of three dots each like those in Fig. 3, corresponding probably to the lower part of the Great Bear. Furthermore, these two stones show the characteristic chariot. The stone of Venslev has above the Great Bear a single dot meant for the Polar Star, and still farther above two groups of dots which are less easy to identify, although one of them in the form of a square may be Cepheus and the other at Cassiopeia; to the right may be seen the characteristic symbol of Auriga. The Dalby stone (Fig. 7) is located on top of a dolmen. Thorkild Gravlund, who discovered these rock carvings, has already identified some of their dots with the Great Bear. The entire stellar figure is thus less clearly defined than upon the Venslev stone. However, it is possible to recognize the Lynx, the Lion, the Virgin, the Bull, with their characteristic stars. The position of the Great Bear and the Lynx with respect to each other is precisely right, as are likewise those of the Lion, the Virgin and the Bull; but the Great Bear and the Bull are much too far apart.

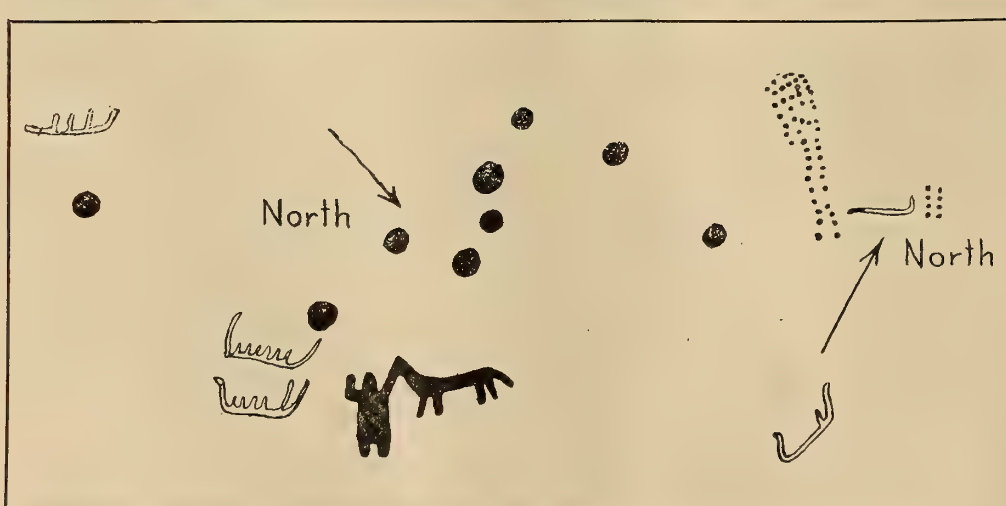


FIG. 5. ANOTHER OF THE ROCK CARVINGS AT BOHUSLÄN AFTER BALTZER, SERIES II, PLATES 1 AND 2

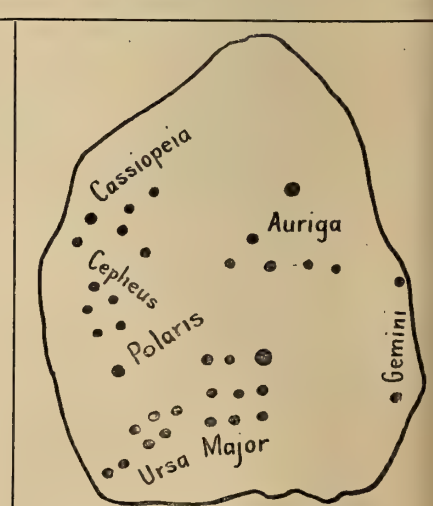


FIG. 6. CARVING AT VENSLEV, AFTER PETERSEN

It is worthy of remark that the most complete specimens among these rock carvings usually represent the skies at specially characteristic times during the year, such as the equinoxes and the summer solstice. This fact greatly augments their religious significance, and indicates their connection with the annual festivals. Furthermore, these astronomical studies may be explained by the fact that the stars already served to guide maritime commerce between the South and the North.

We can but wonder whether these carvings were made from memory or from sketches—for we must discard the third hypothesis, that the rock was carved at night from direct observation, since the work would then have been too difficult. Most of them are no more exact than might be expected if they were engraved from memory. However, at least one of them is so remarkably accurate that it is hard to believe that it could have been made without the help of a model. Possibly the artist made a model at night on a piece of wood and transferred the pattern to the stone by daylight.

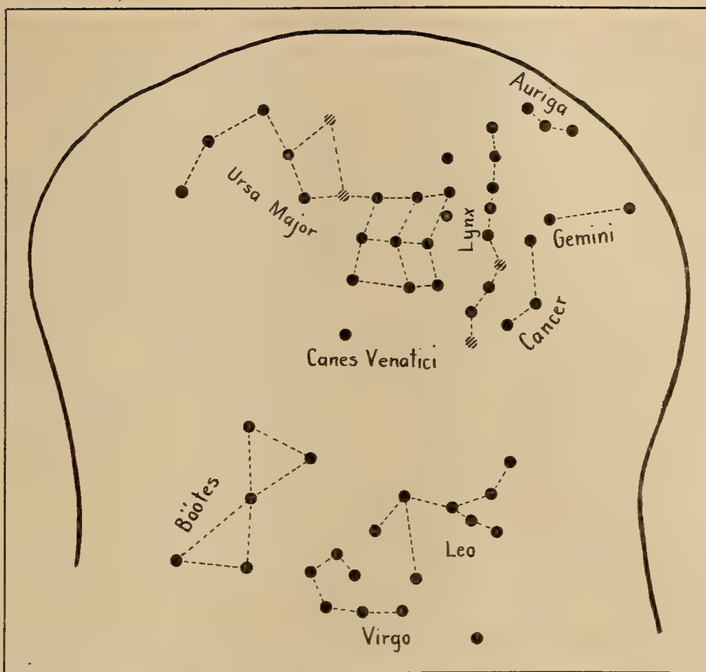


FIG. 7. ROCK CARVING AT DALBY, AFTER GRAVLUND

Skeptical critics will doubtless be found to declare that our theories are based on premises too slight; but certain Scandinavian archaeologists have already made an attempt to prove that even in the Stone Age direct maritime relations existed between the northern part of Jutland and the distant countries lying toward the south.

The present article does but little more than make a preliminary attack upon this very difficult problem, but we hope that this slight sketch will suffice to attract the attention of scientists competent to undertake the study of this engrossing enigma of the carvings upon the rocks of Scandinavia.

Tertiary Man in Flanders Fields*

Fossil Footprints That Show the Evolution of the Human Foot

By Professor W. Freudenberg

A FEW kilometers to the north of the Episcopal city, St. Niclas, an island of heavy clay arose ages ago from the late Tertiary waters of the North Sea at that time warmed by the Gulf Stream. The Scandinavian Peninsula was still united with Scotland by a bond of *terra firma*, forming a barrier against the cold winds and icy ocean currents of the north. The climate along the coasts of that ancient North Sea fed by the English Channel was at that time probably even warmer than it is today in the English Channel Islands and the Isle of Wight. Palms and bamboos spread their fronds luxuriantly upon the mainland through which roamed droves of a three-toed zebra-like horse. On the Isle of Sylt[1] on the eastern coast of this sea there has likewise been found a tooth of this wild horse, the *Hipparion gracile* and across the water, on the eastern coast of England, blessed at that time with a subtropical climate, there likewise lived droves of these same ancestors of the zebra as well as antelopes, gazelles and the most various kinds of thick-skinned animals, the rhinoceros and the elephant and even the mastodon. Thus we see that there actually existed an African fauna along the borders of the North Sea before the appearance of those masses of ice from the inland regions to the north, which brought with them their polar tribes of the musk deer, the Arctic fox, the woolly-haired mammoth and the Siberian rhinoceros.

But how long has it been, we may ask, since such a climate prevailed and such animals were seen along our northwest coast? If we reckon "the post-glacial period" with the coast outline and the climate of today at about 25,000 years, then the glacial period itself may be safely assumed to have lasted for half a million years. But the later Tertiary epoch up to the time that these herds of antelopes and zebras appeared upon the earth, lies fully a million years behind us.

HUMAN BEINGS OF THIS PERIOD

But now further questions arise in our minds: Did human beings exist at that time, and if so, what did they look like and what did they live upon? Is it not probable rather that they were intermediate forms somewhat like the *Pithecanthropus erectus* found in an early glacial stratum upon the island of Java? The data obtained from that remarkable find from the aforesaid little island in the delta of the mouth of the Pliocene Scheldt do not justify us perhaps in answering these questions with a positive affirmation; they are mere sign-posts but none the less worth noting. To begin with, let us inquire how it is possible for us to speak confidently of the existence of an island or a peninsula or even of a zone of shore in those ancient times, in a locality where there is today nothing but a flat and sandy plain. We should not be able to answer these questions without the aid of the spades and the drills of geologists. These men of science are able to recognize when and how the formation occurred of any sort of ground, whether its material be clay or sand or the moraines that mark a glacier's path. The degree of development of those sea mussels found in that sort of clay from the ocean bed gives to the geologist an indication of the time when this deposit occurred, and he may be helped in forming his estimates, moreover, by the fossils of the fishes or the drowned land animals,[2] which may chance to be found there also. In the case in hand there may have been mud deposited in the neighborhood of the coast, at a depth of about 100 meters, let us say, and this slime or mud may itself have become firm

*Translated for the *Scientific American Monthly* from *Die Umschau* (Frankfurt A. M.), for Dec. 11, 1920.

[1]This extremely valuable find, which was made in the micaceous clay of the Isle of Sylt, is preserved in the Museum of the Geological Institute at Hamburg.

[2]A small marsupial animal has recently been found in the Septarian clay at Antwerp.

land by reason of a retreat of the sea from the land at that point. The shore thus left dry would be changed in shape and outline at a much later period by the streams and the storms of the land. Thus there was formed a little circle of islands not unlike our Friesian Islands, but on a much smaller scale and with a partial connection of the islands with the solid land, like the islands of the delta of the Rhine. We must next suppose that through a sinking of the coast the sea surged up upon the land once more, after the ocean had reached its greatest depth. This happened, in fact, at the time when droves of three-toed horses were sweeping across the continent from China to Portugal, to Jutland, and to England, when a continental steppe climate spread over wide areas of the continent of Asia and Europe, accompanied by a similar spread of the fauna proper to such a climate. *It was at this time, according to our assumption, that man made his appearance.* His ancient tertiary and middle tertiary ancestors had been dwellers in subtropical forests. They belonged to a well-known race of anthropoid apes, we may believe, though this is not the proper place to discuss the mental qualities of those European anthropoids of Middle Tertiary times. Yet we may assume, I think, that matters stood thus with our corporeal ancestors if we admit that the intellectual life of man must be regarded as something of a peculiar nature and slow in development in relation to the race history of humanity. Let us inquire then as to what hypotheses may be suggested in these matters and what scientific conclusions it is possible to arrive at. As a geologist and a palaeo-biologist I am obliged to believe that these first members of the human race developed under external conditions such as those which have aided in the evolution of the most intellectual races of today. By this I mean that they were plainsmen—dwellers upon the open steppes. Here we have conditions highly favorable to the constant stimulus and consequent development of the functions of the brain of those anthropoidal ancestors of ours—creatures whose structure of body and degree of mentality resembled those of the great anthropoid apes—who had hitherto found their homes amid dense forests or in dark and narrow caves. For on the plains we have the open horizon with its implied demand for that estimation of distances which is a matter of such great importance to wayfarers across deserts or steppes, since an erroneous estimate all too frequently brings starvation in its train; here, too, man is vouchsafed the unhindered observation of the stars. It is evident that the vast sweep of the heavens above and the far-flung line of the horizon below tend to develop in the nomads of the plains and in the sons of the desert that power of measuring and reckoning—of calculation, in short—whose further evolution we observe in the seafarer and in the merchant.

Unsightly enough are the *footprints left behind him for our inspection by the Tertiary man at Hol by St. Gilles in Flanders.* These consist of impressions of the ball of the foot in which are plainly seen the marks of the papillary ridges and furrows—so clearly marked are these indeed after the lapse of a million years that they might attract not only the investigating eye of a studious anthropologist but that of a modern detective! Even the small toe has left its imprint—only half that of the fourth toe, however, is visible in the impression. This footprint, now hardened into stone, was once impressed in a lump of the tenacious Tertiary clay which formed the aforesaid shore or island and as the foot that made it strode away it was kicked off into the sands of the dunes. When, toward the end of the Tertiary period the Middle Pliocene North Sea flooded the islands of the Scheldt it spread over the clay which composed them the sediment borne in the raging waters. These imprints of human-looking toes hardened into solid stone and as such they remained upon the shore of the steadily southward spreading sea.

What was the creature who left these footmarks doing there? Was he really a man or merely one of a race of anthropoid apes, traces of which have already been found in the older Tertiary strata and which we recognize by their bony remains and their teeth? To begin with, while we may concede that these creatures were quadrupeds they were by no means ape like since the toe prints are all short—for that matter our own babies might be said to be quadrupeds at an early stage of their existence. How skilful the use an infant often makes of the soles of his feet and of his still mobile and unatrophied toes! And does not the fact that France has produced both a painter and a tapestry maker who, lacking hands, accomplished their work with their feet, offer proof enough that our Tertiary ancestors of a million years ago were four-footed creatures?

The anthropoid apes of today, the gibbon, orang-outang, and the chimpanzee with their many species and subspecies (in the case of the gibbon) all have long, climbing toes upon their feet: this is more marked among the apes of the East than among the anthropoid apes of the West, the chimpanzee and the gorilla, which possess the shortest toes by far among all the group of our nearest animal relations. This indicates that the foot is in these creatures not exclusively a climbing organ, but that they use rather the toes of the foot as a highly sensitive lever in order to balance the heavy body when in an upright position, just as human beings do when walking. We may conclude, therefore, that these toes which left their imprint so long ago in the late Tertiary coastal zone of Flanders, were constructed upon the same plan and for the same purpose.

Indicated Size of the Tertiary Man.—It is a striking circumstance that the toes which made these tracks were quite small. They correspond in size to those of a four-year-old boy, *hence they must have belonged to a pigmy less than one meter in height.* At the same time it is evident that the impression was made by the foot of an adult. A proof of this is found in the imprint made by the ball of the foot. In the young offspring both of human beings and of the anthropoid apes the tactile ridges and furrows upon the soles of the feet and the palms of the hand lie much closer together than in adults of the same race and sex as may be seen in Fig. 1. During the growth of the individual the skin and those small structures upon it which serve the function of touch become expanded. The ball of the foot of this prehistoric Tertiary man, assuming that it belongs to the same species as the aforesaid toes of human appearance, has the furrows of the tactile papillæ so far apart as to make it evident that the impression was made by an adult foot. The *curvature* of the impression of the ball of the foot, however, indicates plainly that its maker must have been less than one meter tall.

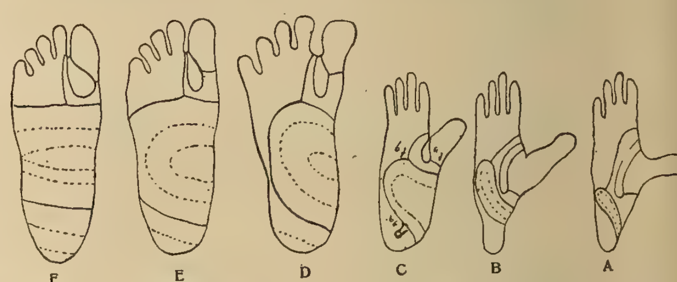


FIG. 1. SERIES OF DIAGRAMS SHOWING THE DEVELOPMENT OF THE SOLE OF THE HUMAN FOOT

A to C, the forerunners of mankind; D to F, the development of the foot from Tertiary man to the present time.

But we cannot avoid the belief that creatures of an anthropoidal nature and walking upright, must have moved about a good deal, even were they not driven by a genuine *wanderlust*, especially if we assume that the reason for the development of a foot so typically human in its aspect is to be attributed to the appearance of a climate like that of the steppes in Europe and Asia north of the Tertiary chain of mountains. The acquisition of such a foot could not have taken place amid dense primeval forests where both men and their rela-

tives, the anthropoid ape, must have remained as they were originally: chiefly tree-dwellers with feet adapted for climbing and with a more or less uncertain gait upon flat ground.

But the footprints of which we speak were found in the vicinity of the late Tertiary seashore. Possibly they were made in the miry ground of the delta at the mouth of the primeval Tertiary Scheldt, which appears especially probable in the case of the print made by the ball of the foot. The impress of the toes, which was found in the sandstone and was made therefore upon a sandy ground, was probably made also in the neighborhood of the sea—perhaps, likewise, on the shore itself—and then covered wiht a fresh layer of sand, which would account for the sharpness of its outline. Upon the under side of this imprint of the toes there is to be seen the impression made by a shell fish which suggests that this primeval man may have sought the shore to hunt for mussels.

A few kilometers to the east of the clay pit at Hol (St. Gilles), where the writer of these lines with the aid of some Belgian workmen, made the aforesaid find in the Tertiary sand-covering of the clay pit of a brickyard during the war, an excavation was made by the same workmen to the north of the locality of Vracene which afforded welcome support to the aforesaid hypothesis. We were digging in the same late Tertiary covering of sand as at Hol (where our discoveries were principally made), but in this new location the sea sand lay in a much thicker stratum above the clay, for the reason that we had left the vicinity of that ancient island of clay, and proceeded in the direction of Antwerp, where a much deeper sea prevailed during the geological epoch in question. This is evident in fact from the remarkable depth of the strata of sand in which the docks of Antwerp have been constructed. But in this locality, also, Septarian clay forms the foundation of the strata of sand. An enormous quantity of whale skeletons came to light during the building of the old harbors and among them were found also a number of the finely notched saw-like teeth, as big as a man's hand, of a giant shark whose present relatives (quite a bit smaller of size), make their home in tropical waters. Such teeth as these, with edges sharp as knives, were also found in our own excavations, especially at the point where the footprint was found, and these offer quite special proof of our thesis, since to all appearance these teeth were eagerly sought for by Tertiary man as valuable work tools, so that when these primitive creatures wandered shoreward they kept their eyes open, not only on the look-out for mussels to supplement their food and for bones and flints for utensils, but also for the huge shark teeth described above to assist them in opening the tightly-closed shells of the still living mussels which were part of their treasure trove. At first thought this may sound like a rather fantastic idea, but it is supported by the fact that one of our finds at Vracene was a number of mussels in the uppermost layer of the Tertiary mussel sand which had obviously been opened artificially by a sharp stroke or cut. As a *proof* that these mussel shells were really of tertiary origin and belonged, therefore, to the *preglacial era* we may note that those mussels which exhibited an incision of artificial origin (obviously intended to cut off the front muscle employed in closing the shell) belong to a species which is not only entirely extinct today but is lacking even in the diluvial strata of the glacial era. They are, in fact, the *Cyprina tunida*, a relative of the Iceland mussel.

Are we not, therefore, quite justified in regarding these ancient Netherlanders of those primeval times as true epicures, knowing how to appreciate oysters, as is proved by the numerous broken shells found at Vracene? We can, in fact, speak of piles of mussel shells, heaped up obviously by creatures more or less human in character along the aforetime borders of the Flemish North Sea, which today lie many kilometers inland by reason of the subsequent raising of the coast line during the glacial period. For there were also times during the glacial period in which the North Sea flowed farther to the south than is the case today.

Less illuminating as to their object than the incisions upon the two-shelled mussels are the regular curving strokes made upon the thick skull bones of an extinct species of whale. The idea suggests itself that some flexible material such as, perhaps, the skin of a seal, a walrus or sea cow (which at that time had not retreated toward the south) may have been rubbed against these grooved skull bones in order to rub off the fatty tissue clinging to it. This kind of manipulation would, of course, indicate quite a considerable degree of intelligence and skill. Often, too, they may have employed exceedingly sharp fragments of flint which are found among the deposit along tertiary shores. However, we cannot be quite sure of the artificial origin of these splinters of flint. All the more important is the discovery of what are *undoubtedly artificially shaped flinty stones* of the same period, *i.e.*, in the upper tertiary strata in the vicinity of Aurillac in southern France, by Professor Verworn of Bonn. We may assume, therefore, that tertiary man was clever enough successfully to shape tools from flint. This alone indicates a great step in advance over apes.

An Engraved Mussel Shell.—In the English Red Crag which is likewise a late tertiary shore formation, there has been found an engraved mussel shell upon whose convex side a human face has been crudely carved. It looks, to be sure, like the scratching of a child and yet this reddish stone still firmly retains the lines graved by this first exponent of the plastic art. There is a small hole bored through the "backbone" of the shell, so that the mussel could be worn as a pendant. To a period somewhat later at about the turning point between the tertiary and the diluvian, we find the *most ancient man upon English soil* in the form of the skull and the lower jaw of the *Eoanthropus*. The former exhibits external features more human in character but it contained the most primitive brain ever found in the skull of man. The lower jaw is quite ape-like with a shovel-shaped projecting snout. So different is its aspect from everything that we call human today, that it was at first thought by geologists to belong to a chimpanzee.

However, even today there are found in England men with lower jaws of a low degree of development—an inheritance, perhaps, from these primitive men. On the other hand the *most ancient middle-European ever found*, the *Homo Heidelbergensis*, exhibits purely human features in the form of the teeth together with a very remarkable, but not especially apelike lower jaw. The third example of human remains likewise in the ancient quarternary was made in Java. This is the celebrated *Pithecanthropus erectus* whose upright carriage indicated by the thigh bone is combined with a very ape-like brain pan. Thus we have to discriminate between *three different species of primeval man at about the turning point of the tertiary period.* It seems probable that in other parts of the world, at about the same period of time there must have existed other markedly different forms of primeval man.

Instead of coming nearer to a common origin of man, as the ancient lore of church and school teaches us, and as even universities have been accustomed to hold, the farther we trace man back to a possible origin the more different in nature are the various races of man. Indeed there are *absolutely definite points of resemblance between certain races and the anthropoid ape.* According to our hypothesis we must regard human beings as correlated forms of evolution, as adaptations to a certain form of environment. The upright gait and the nobly arched skull must in the final analysis be regarded not as a common inheritance, but as a highly complex adaptation to the steppes or plains. To begin with, naturally, the region of the Asiatic steppes furnishes the original home of the modern sort of mankind, but it is also true that that realm of Europe which was transformed from a primeval forest into a great bare plain or steppe—particularly in the vicinity of the mountains with their numberless stimuli for the development of the human foot, must have been centers of creation for humankind.

Fish That Chew Their Cud

Confirmation of Aristotle's Claim That the Parrot Fish Should Be Classed as a Ruminant

As far back as the 4th century, B.C., Aristotle set it down as a curious fact in natural history that the parrot fish is to be classed among ruminant animals. This story was repeated by the Roman writer on natural history, Pliny. Both of these ancients doubtless had in mind the *Scarus cretensis* L., which was found more or less plentifully in the eastern part of the Mediterranean Sea. However, the story passed as a fable, like so many other ancient statements of fact since verified. These fish possess certain peculiar pocket-like extensions of the mucous membrane of the mouth, which serve like the cheeks of a squirrel or like two throat-pockets to hold food. A German writer, Dr. Fritz Reuter, gives a brief but entertaining account of these fish and their unusual habits of alimentation in *Kosmos* (Stuttgart) for November, 1920, from which we take the following paragraphs:

"The beak-formed jaws of the parrot fishes are covered with teeth, which are not only firmly attached to the jaw bone but also to each other. In young animals of some species the rows of teeth, which are arranged like the teeth of a comb, can still be clearly discerned. But in other species the fusion of the separate rows of teeth has proceeded further. In the *Scarus* and the *Pseudo-Scarus* the fusion has become so intimate that the original boundaries of the separate teeth can only be surmised from the rigid formation of the edges of the jaws.

But with these beak-like jaws the parrot fish can only bite off their food and not grind it, since the jaws are capable of no motion except a mere opening and shutting. Furthermore, the knife-like edges of the jaws are so sharp that they clearly indicate that the jaw plates are never employed as grinding teeth.

But besides these the lower throat bones which form the five branchial arches on each side are fused into an irregular plate which is covered with teeth of a peculiar form. This dentated plate projects distinctly above the surface of the surrounding mucous membrane. The very powerful upper bones of the gullet are attached in such a manner as to move back and forth in grooved hollows of the base of the skull; in consequence of this arrangement they are able to produce the grinding motion which, as we have seen, is impossible in the case of the toothed plates of the jaws. These bones bear three longitudinal rows of serviceable teeth, which correspond to the dentated plates of the lower throat bones. It is by the rubbing or grinding back and forth of these upper plates upon the lower ones that the vegetation which forms the fishes' food is ground into a very fine state.

The entrance to the cheek-pockets mentioned above lies very close to the lower dentated plate of the throat. Immediately behind the grinding plates the cavity of the jaws rapidly grows narrower, merging into the comparatively small gullet. As a matter of fact the contents of the stomach of the parrot fish are ground so finely as almost to form a sort of broth whose composition is very difficult to determine even with the microscope, so small are the particles which compose it.

Surrounding these cheek-pouches are strong muscular fibers forming a thickness swelling of the mucous membrane, whose contraction forces the bitten off food farther to the rear. In front of the upper gullet plate the mucous membrane forms a thick fold corresponding to the swelling of the lower part of the gullet mentioned above. This fold is probably intended to press the bitten off pieces of food into the cheek pouches.

The content of the pouches, *i.e.*, the nutriment of the fish, consists chiefly of algae, but also contains bitten off pieces of hydroid polyps and prongs of silicious sponges, as well as fragments of corals. All these bits of food in the pouches are found in small pieces but by no means reduced to the broth-like fineness of the contents of the stomach. As a matter of fact an actual process of "chewing the cud" takes place in these fishes. With their sharp jaw teeth, working up and down like a pair of shears, they bite off from the rocks of the coral reefs, in whose vicinity they live, pieces of food material. The steady current in the water produced by their respiration facilitates the rearward movement of these bitten off pieces of food material. A sort of valve arrangement prevents these from reaching the gills, and by the contraction of the muscles in the swollen mucous membrane they are forced into the cheek pouches. Later when the fish has grazed sufficiently, so to speak, in these meadows of algae, it seeks a quieter place in order to be undisturbed in its digestion, and at this time the contraction of the pouches forces the food they contain back into the mouth cavity, where it is chewed fine in peace and quiet—exactly as is the case in the chewing of the cud of our domestic cattle. In other words the regurgitated food in the mouth is ground or rubbed into a liquid condition between the upper and lower grinding plates. When the fish is at rest this grinding motion can be plainly observed, and it was this without doubt which led the ancient authorities mentioned above to make their happy comparison of this process with the chewing of the cud in domestic ruminants.

The magnificent colors of these fish are familiar to visitors in all our great aquariums—colors which quickly fade when they are taken out of the water. They have been celebrated, too, from the earliest times for their appetizing qualities as food fishes. Pliny even declared that this fish was the choicest dainty of all. . . . On account of this delicacy of flavor the Emperor Claudius took special steps to transplant these fish from their original homes along the eastern shores of the Mediterranean to the west coast of Italy, decreeing that for a period of five years all the parrot fish caught in these waters should be thrown back into the sea, by the end of which time they were well established in their new habitat.

THE EFFECT OF LIGHT ON SO-CALLED EYELESS ANIMALS

Some curious and instructive experiments have recently been made by Prof. Paul Kammerer, of the Biological Institute of Vienna. This institute possesses a very deep cistern and it was found that the salamander born in this cistern differed from the parents only through a smaller size and through their plainly recognizable eyes, which were visible through the thin skin covering them, resembling poppy seeds. One of these animals was exposed to light and the consequences were noteworthy. The hitherto colorless skin turned black and the eye also regained the usual dark color. On this account a ray of light must be chosen which contains no color. For this reason a red lamp was employed. One animal was exposed to this light for five years and five animals were exposed alternately to the red light and to daylight. In the latter five animals a formation of pigment was clearly seen which, however, was not sufficient to cover the eye. In the ordinary cave-living salamander as it increases in age there is a disappearance of the cell of the cellular lens, but in the animals exposed to light, as above described, the eye was eighteen times as long and twelve times as broad. The skin was found to have become extremely thin over the eye, a regular pupil and iris being visible.

By tests made with proper food it was found that these animals were quite well able to see. These experiments plainly show that the ancestors of the so-called eyeless cave fish possessed eyes which gradually became atrophied through their changed conditions of life, but whose rudiments are still possessed and can be made to develop.

THE NEST OF A HORNET SHOWING ITS THIN PAPER-LIKE ENVELOPE

THE SAME NEST BROKEN OPEN TO SHOW THE CELLS WITHIN

Hornets and Other Social Wasps

Nest Building and Community Life Among the Vespidae

ONLY less fascinating as a subject of study than their close relatives the ants and the bees are the wasps, whether the true wasps which like ants and bees are citizens of highly organized social communities or the so-called solitary wasps. As John Burroughs has remarked this study "opens up a world of Lilliput right at our feet, wherein the little people amuse and delight us with their curious human foibles and whimsicalities and surprise us with their intelligence and individuality."

All of the true wasps belong to the *Diploptera*, a division of the suborder *Aculeata* in the order of the *Hymenoptera*. The *Diploptera*, which comprises more than 1,000 different species may be conveniently subdivided into two groups, according to their habits of life. One of these is the *Vespidæ* which includes all the social wasps, including the hornet or *Vespa crabro* and the common wasp or *Vespa vulgaris*. The other group contains the solitary wasps, the *Eumenidæ* and the *Masaridæ*.

The social wasps greatly resemble bees in their manner of living, their communities consisting of males, females, and neuters or workers. However, the community is not perennial like that of the bee but merely annual. Most of the colony perishes when summer passes but a few females which have been mated take refuge in sheltered places, such as hollow trees or overhanging rocks and hibernate till the following spring. When such a female is roused from her torpor by the balmy airs of the warm season she comes out from her castle of refuge and at once sets about her business in life of founding a new colony.

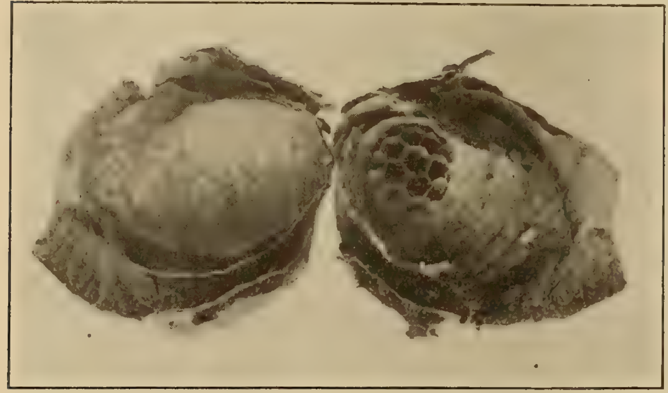
The common wasp usually selects a hole in the ground enlarging it to suit her needs; she then begins to build her nest. For this purpose she gnaws off bits of wood from convenient sources and "chews" these into a sort of pulp mixed with saliva, until she has a mass much resembling the "spit balls" with which naughty boys sometimes enlivened the schoolroom of our childhood days. This sort of natural *papier mâché* is the wasps' building material. Some of it is shaped into a hanging pillar—a sort of stalactite hanging from the roof of the chosen cavity. In the lower free end of this column, three shallow cup-shaped cells are hung, and in each of these an egg is laid. The capable builder of the colony now continues to add new cells, placing in each the appointed egg. Meanwhile the first-laid eggs soon hatch into grubs and the busy mother must add to her labors by feeding and tending her offspring.

The grubs are oddly shaped little creatures, being thicker in the middle than at the two ends. They are suspended in their cells head downward, and they give their fond mother a considerable amount of trouble, for she first carefully chews the insects which form the usual *piéce de resistance* of their diet. Since all this time the mother wasp is adding new cells, her work is obviously "cut out" for her. It takes about eight days for an egg to hatch and the grub must be fed for a couple of weeks longer, after which it spins a silky cover to its cell and becomes a pupa, emerging as a perfect insect at the end of ten days more. The new-born insect either pushes the cover out with its head or bores a round hole through it. And now another task awaits the thrifty housewife; while her offspring flies gaily off to seek its fortune in the world, the mother carefully cleans out the apartment just vacated and lays a fresh egg in it, so that sometimes the same cell has several lodgers during the summer. However, the mother is assisted in her herculean labors by her first born offspring, since these are all neuters and are set promptly to work in caring for the home, enlarging the comb, and feeding their younger brothers and sisters.

The fact that only workers appear during the first half of the summer is probably connected with the greater scarcity of food at that time. As fruit begins to ripen on the trees and spread its largess to the insect world, food becomes more abundant, and fully developed females and males emerge; these are larger than the workers and, therefore, require larger cells for their development. They are usually kept apart from each other and from the workers. Strange to say the males develop from non-fertilized eggs laid by the later broods of workers and developed through parthenogenesis. They have no stings and may be distinguished by their more slender bodies and their longer antennæ.

In a good season when the sun is kind and the harvest abundant, a single nest may contain several thousand cells full of wasps in various stages of development, since each cell is occupied two or three times some authorities estimate that

a single community may comprise 30,000 insects. The combs are arranged horizontally, and contain a single layer of cells, opening downward. The second comb is suspended from the first by a number of hanging pillars which are built from the point of union of three cells. The space between two combs is just sufficient to allow the wasps to cross each other. The combs are roughly circular in outline, and increase in size for the first four or five layers, after which they begin to decrease; the whole is covered by a roughly made coating of the same papery substance which composes the combs. This at first forms a cap-shaped protection, but as each comb is built it is continued down until finally it forms a roughly spherical covering for the whole, but not giving any support to the combs, which are independent of it. The covering is pierced by apertures for the passage of the wasps. The cells are hexagonal at their mouths, but above become more rounded in their cross-section.



A NEST OPENED TO SHOW ITS FORMATION

HORNETS (*Vespa Crabro*)

While not all wasps are hornets all hornets are wasps. They are larger in size than a common wasp and more reddish in color. They may be distinguished also by the row of red spots on each side of the abdomen.

Their nests resemble those described above, but are larger; they are found in hollow trees or deserted outhouses. Their communities are smaller in number than those of common wasps.

The hornet where it occurs in any number does a considerable amount of damage to forest trees, by gnawing the bark off the younger branches to obtain material for reconstructing its nest. It usually selects the ash or alder, but sometimes attacks the lime, birch and willow. Like the wasp it does much damage to fruit, upon the juice of which it lives. On the other hand, the wasp is useful by keeping down the number of flies and other insects. It catches these in large numbers, killing them with its jaws and not with its sting. It then tears off the legs and wings, and bears the body back to the nest as food for the larvæ. Wasps also act to some extent as flower fertilizers, but in this respect they cannot compare with bees; they visit fewer flowers and have no adaptations on their legs for carrying off the pollen.

The genus *Vespa* is very widely spread; it contains over forty species, distributed all over the world. Some of the largest and handsomest come from eastern Asia. *V. mandarina* of China and Japan, and *V. magnifica* of the East Indies and Nepal, measure 2 inches across the wings; *V. orientalis*, found in Greece, Egypt, and the East, builds its nest of clay.

The only other genus of *Vespidæ* which is found in Europe is *Polistes* which occurs in the countries bordering the Mediterranean. The colonies of this genus are much smaller than those of *Vespa*. Each nest consists of a single tier of cells in the form of a round plate, supported in the middle by a single stalk. This comb is sometimes vertical, the cells then being horizontal or slightly oblique. Some of the members of this genus store up honey, which in the case of a South American species is poisonous, from the nature of the flowers from which it is gathered. The members of this genus have a slender body; the thorax is more oblong than in the genus *Vespa*, the palps stouter, and the abdomen more distinctly peduneulate.

The hornet, known to European naturalists as the *Vespa Crabro*, is known in this country, where it found a habitat many years ago, becoming Americanized with much less difficulty than some of our emigrants. Is more generally known in this country as the *Vespa maculata* among naturalists. It is sometimes popularly called the white-faced hornet, since the head is marked with white, while the body is black. It is the largest and fiercest of all wasps—many people, by the way, may be surprised to learn that it really is a wasp, since its body has none of the slender elegance, which has made the term "wasp waist" a proverbial expression. It is very irascible and its sting inflicts a really painful wound. Moreover, it will pursue those who meddle with its nest, whether purposely or accidentally, for long distances. A friend of the writer declares that he discovered when a boy that the only way to escape one of these insects when angry was by suddenly hiding behind a bush or a tree, whereupon the hornet appears to be baffled. One of our illustrations shows a fight between a hornet and a bee, in which the former appears to be getting the best of it. Some of them, by the way, not content with attacking ripe fruit for its sweet juices, do not hesitate to kill bees and rob their hives of its honey.

While the name yellow-jacket is rather indiscriminately

A HORNET (*VESPA CRABRO*) ATTACKING A COMMON BEE

THE *POLISTA* WHICH BUILDS ITS NESTS WITHOUT AN ENVELOPE

WASPS SUCKING THE JUICE OF A PEAR

THE HANGING COVERLESS NEST OF THE *POLISTA*

applied to any wasp marked with yellow, even including the hornet, it is usually applied in America to the common wasp *Vespa vulgaria*.

MATERIALS OF THE NEST

A very notable feature in the building of wasps' nests is the neatness they observe. When the cavity in the ground has to be made larger, which is very often the case, the particles of earth excavated are not merely dropped outside but carefully picked up in the mandibles of the insect and carried to a considerable distance. Since the earth thus excavated is spread over a very wide area, it leaves no trace of the locality of the nest. The paper pulp produced by the wasp's mastication of wood, or sometimes of scraps of paper or pasteboard, soon dries into a sort of brown paper, streaked with paler bands according to the nature of the wood employed. Thin as this paper is, it keeps the brood warm enough to hatch because of the method in which the nest is made. The latter consists of broad overlapping scales arranged in numerous layers. These hold air between them so that the finished structure which holds the eggs and infant creatures keeps them as warm as a "bug in a rug." Fabre declares, indeed, that when the weather is hot the temperature must be actually tropical within these apparently flimsy shelters.

When the colony is considerably advanced so that there are a number of disused cells the workers attack these and reduce them to pulp to be used in the manufacture of new cells. They prefer, indeed, to work over this old material since their task is easier than with fresh wood.

METHOD OF FEEDING THE YOUNG

The larvæ are blind and like human babies they spend much of their time in sleep. When their mother or nurse arrives at the door of the cell she, therefore, wakes the grub with the tip of the antenna, whereupon the infant gapes greedily, like a young bird at the sight of a worm. Being blind, however, the larva must swing its head about a bit in order to find the nurse's mouth and receive a drop of nourishment. In the process of transferring the ration, the larva often fails to receive the full amount in its mouth, but nature has provided against waste by a very accommodating arrangement. When the grub is receiving its food its neck swells so as to catch any escaping particle, like a broad napkin spread over the chest of some bucolic trencher-man. These precious drippings are neatly licked off by the infant grub whereupon the swelling recedes.

While the etymology of the word *hornet* is rather uncertain it appears to signify the horn bearer—thus we have in Old Low German the equivalent *horn-beron*. However, authorities differ as to whether the reference is to the antennæ, which project like horns, or to the buzzing noise made by the insect, which might be fancifully compared to that made by a trumpeter or "horn-bearer." The sound is certainly sufficient to strike terror to the heart of any unlucky wight who has had the misfortune to "bring a hornet's nest about his ears"—a phrase by the way which has become proverbial in its figurative sense.

RUTHLESSNESS OF WASPS

In spite of the remarkable social instincts of wasps—or shall we say because of them—they seem lacking both in intellect and the higher emotions thus, a wasp mother is said to ruthlessly put to death any of her offspring which she

NEST OF *POLISTA* SHOWING THE TRANSFORMATION OF GRUBS INTO NYMPHS

finds unduly feeble or deformed. Mr. and Mrs. Peckham, who have devoted much time to the study of wasps, give an account of several interesting experiments to prove this point: Thus, they killed a number of wasps and placed them near the nest; their surviving relatives displayed neither grief nor alarm, but at once set about cutting up the bodies by way of a convenient food supply for the youngsters! Again, these observers placed some tempting dainties at a distance from the

nest, to see whether the first discoverers of the repast would spread the glad news as ants are in the habit of doing. Not so! The first two or three who happened to chance on the booty would fly back and forth all day, keeping the secret of their treasure trove to themselves.

VESPA ARBORASTORUM OR TREE LIVING WASPS

While common wasps and a closely related species *Vespa Germanica* which is likewise found in this country as well as in Europe, build their nests in an underground cavity, the small wasps known as the *Vespa arborastorum* suspend their nests from trees.

POLISTA GALLICA L.

Some of our illustrations show another interesting wasp, the *Polista*. This insect is from 12 to 16 mm. in length, having a black body with numerous yellow spots or marks. A characteristic feature of their nests is that there is no external envelope such as described above as covering the nests of other social wasps. Usually the nest consists of a simple row of cells with which a second row is connected by means of columns. As in the case of other wasps' nests the cells are hexagonal in shape and consist of sort of brown paper; a large pedicle attaches them to the chosen support and this is always selected in a warm locality which explains the lack of a covering. As our picture shows this curious construction of the nest makes it look not unlike an inverted mushroom.

FOOD OF ADULTS AND LARVAE

While the larvæ of wasps are said to be chiefly if not entirely carnivorous in their diet, though Fabre successfully fed them with honey in some of his experiments, the adult insects have a very pronounced "sweet tooth," if the expression is permissible. They are very fond of sugar as well as of honey and sweet juices, and many a housewife has been annoyed by their enthusiastic and determined forays into her kitchen, when she was making preserves.

When they find a supply of sweetmeats or other attractive dainties at a considerable distance from the nest, wasps pay little attention to other insects likewise attracted to the feast, but when the banquet is spread near their own nest, they at once sit up and take notice, so to speak. They warn the intruders off at first gently and amiably enough, by a blow of the legs, but if the unwelcome guests neglect to take the hint and especially if they approach too near the nest, whether drawn by greed or curiosity, or merely through ignorance, they are immediately killed and thrown to the bottom of the excavation in the earth, which is, in fact, an actual slaughter house, wherein are thrown not only such victims but malformed larvæ and eggs which have failed to hatch properly.

There is one curious exception to this stern law of death to intruders, and this is practised, not by way of hospitality, but merely as an economic convenience as it were. The *Volucella* is a large fly which is permitted to lay its eggs in the nest, where their larvæ, when they emerge, act the part of scavengers, disposing of the refuse produced by the excreta of the wasp larvæ. These fly larvæ crawl in behind each wasp pupa and collect the dejecta which otherwise might make the nest unsanitary.

While flies, worms, etc., are captured and masticated to serve as a sort of predigested food for the larvæ, wasps also eagerly enter butchers' shops where meat is exposed and cut off bits of it to carry home. Some species such as the sphex also paralyze caterpillars, so as to furnish a supply of living though torpid food for their offspring. (See SCIENTIFIC AMERICAN MONTHLY for November, 1920, p. 222.) Some wasps attack spiders, mutilating the bodies if necessary in order to carry them conveniently to the larder. Others rather specialize on grasshoppers, and these, of course, are real friends of the farmer, more than repaying him for their minor thefts of food or honey.

THE UPWARD TRANSLOCATION OF FOODS IN WOODY PLANTS

IN the *American Journal of Botany* for July, 1920, Dr. Otis F. Curtis of the Laboratory of Plant Physiology of Cornell University gives an account of experiments made to determine whether or not there is an upward translocation of foods in woody plants.

In one group of experiments large numbers of twigs and branches were ringed early in the spring while the buds were still dormant or were just beginning growth. These rings were made at different distances from the tip in order to determine from how far back food was withdrawn for shoot growth. Since, as was shown in a previous paper of the author's, no appreciable upward movement of foods occurs through the xylem, the growth of a shoot above such rings should serve as an approximate measure of the amount of food available. If the ring were back far enough from the growing tip to allow for growth practically as great as that on unringed twigs, it would seem that these twigs need not draw on the food stored at greater distances.

A large number of stems of *Acer saccharum* were ringed on April 5 at different distances from the tips. In one series the rings were in the first-year wood, in another in the second- or third-year wood, and in another the rings were in that part of the stem ranging from five to fifteen years old. Some of the stems had made terminal growths in the previous year of from only 10 to 20 centimeters, while others had made growths of from 20 to 40 centimeters. In each case a check stem was chosen as nearly matching the ringed one as possible. The check and ringed stems were usually the two terminals of a pair produced by dichotomous branching.

Of 15 twigs ringed in the one-year-old wood, the average terminal growth on May 6 was 0.84 cm. That of the corresponding stems not ringed was 2.22 cm. Of those ringed in the two- and three-year-old wood the average terminal growth was 2.03 cm., while that of the corresponding checks was 2.25 cm. The leaves of the ringed stems in these cases did not show the bronze tinges that were common in the normal young leaves, but were a bright green. At the same date, May 6, there were no apparent differences in the growths of stems not ringed and of those ringed back on the 5- to 15-year-old stems. On May 25 measurements were made of these stems. An average of the shoots of ten stems of this series showed a growth of 9.96 cm., while that of the corresponding check stems was 11.09 cm. The older stems, whether the diameter was large or small, showed growth fully as great as that of those not ringed, but some of the younger stems showed somewhat lessened growth which lowered the average for the growth of ringed stems. In most cases growth had ceased and terminal buds were beginning to develop at the time of measuring. In another experiment a number of stems of a pear tree growing in sod were ringed. These stems ringed in the one- and two-year-old wood showed distinctly lessened shoot growth, but those ringed where the diameter was from 1.5 to 3 cm. showed growth fully as great as that of the unringed stems.

The data collected from these and other experiments show that shoot growth is fairly vigorous when no food further back than that obtained from a branch about one centimeter in diameter is available, and that when the ring is no further back than the 5- to 10-year-old wood, the growth of the shoots above the ring approaches more and more nearly that of the unringed stems.

Discussing his results, Dr. Curtis says that even if one could use large numbers of uniform stems that have been grown under uniform conditions, it would be difficult to determine from ringing experiments alone as to the exact distance of upward movement, for a check in growth may result not from lack of food but from lack of water due to the fact that no new xylem would be formed in the region of the ring, because in some trees much of the water may be carried through this new xylem.

Why Roots Grow Downward*

The Modern Statolithic Theory of the Geotropic Action of Roots

By Hermann Van Guttenberg, Berlin-Dahlem

SOME twenty years ago there appeared in the *Reports of the German Botanical Society* two articles, which attracted widespread attention not only among the professional botanists but among laymen. These articles contained the first statement of the so-called statholithic theory of the geotropism of plants. The two well-known botanists, G. Haberlandt and N. Nemec, had arrived quite independently at the common conclusion that the sensation of position in plants and the twisting motions dependent thereupon—in brief their geotropism or earthward turning—might be explained by the capacity for alteration of location possessed by certain bodies contained in the cells, just as the sensitiveness to position of animal organisms is explained by the theory of the so-called "statoliths" located in the statocysts, which constantly follow the pole of gravitation. Twenty years is no inconsiderable period in the realm of modern scientific investigation, hence it may be well worth while to undertake a brief examination of this theory to see how it has "stood up" under the test of time. Let us begin with a brief statement of the features of the theory. The idea that there might be found formations in plants analogous to the statocysts discovered in plants was first suggested by Mall in his work entitled *Concerning Heterogeneous Induction* (Leipsic, 1892), and *concerning geotropism* (Yearbook of Scientific Botany, 1900). Since, however, he had no exact knowledge concerning such bodies, he assumed the existence of minute invisible bodies, which he called "centrosomes" present in so-called "centrospheres" and assumed that the location of the hypothetical bodies was in the quiescent external plasma skin—meanwhile Haberlandt and Nemec made the discovery that there actually exists in the cells of plants certain bodies which are capable of changing their position, and a systematic investigation of these soon showed that such bodies are regularly found in certain plant tissues. Above all they noted that the starch grains contained in leucoplasts or chloroplasts very generally possess a greater specific gravity than that of the surrounding plasma fluid, as a result of which they sink. Any inclination of the plant organ containing them occurs at once to that portion of the cell wall which has, for the moment, the lowest position. Besides these starch grains there are also found crystals and cell nuclei which are capable of changing their position upon occasion.

Now, if we assume that the motionless external plasma skin is sensitive to the pressure of the "statolithic" starch grains we have at once a very simple explanation of the manner in which plants are able to perceive the direction of the pole of gravity, and how they can be acted upon by gravitation as a stimulus. For it is obvious that various portions of the plasma skin will be subjected to the pressure of the starch grain according to the manner of inclination of the plant organ, and a definite position of the starch grains will correspond to the normal position of the portion of the plant in question.

The advocates of this theory were able to prove to begin with that all of the higher plant forms possess such arrangements, and that at the very locations in which the stimulus of gravity is perceived. This becomes especially significant where a strictly localized geotropic sensitiveness exhibits itself as in the extreme point of the roots and in the points of the cotyledon sheaths. In the first case there is the heaping up of movable starch grains in the cap of the root, while in the latter case this heaping up is found in the spatulate portion of the point. In the stem organs such starch grains are found in the sheath of starch surrounding the circle of vascular bundles in plants whose stems are divided by so-called nodesas, for example, in the grasses.

It was soon agreed that this theory was in perfect harmony with the anatomical and psychological data at hand. And nothing has occurred to change this opinion up to the present time, since the very latest facts learned by observation agree most admirably with the demands of the theory. When the opponents of the theory, however, pointed out that in many of the geotropically sensitive fungi no one has, as yet, found analogous bodies capable of altering their location, the only answer to their objections was that we are also familiar with certain lower animals who exhibit a sensitive reaction to position in spite of the fact that they possess no statocysts—yet thus far this fact has induced no one to deny the importance of the statocysts in other animals. . . . Kreidel has shown in fact that there are certain *Garnelen* which, instead of the usual statoliths, contain particles of iron in their statocysts and, consequently, react not only to the force of gravity but to that of magnetism.

RESEARCHES UNDERTAKEN IN SUPPORT OF THIS THEORY

Various attempts were made to produce evidences either for or against this theory by the removal of the statolithic starch grains. This proves to be very difficult, however, since it has been found that plants retain an extraordinarily tenacious hold upon this starch, which very fact indicates that the said starch grains cannot be regarded merely as reserve stores. When the said attempts were finally successful, however, and the disappearance of the starch was occasioned by such methods as starvation, the raising or lowering of the temperature, treatment of certain chemicals, etc., yet the objection could not be answered that the absence of geotropic twistings was due not merely to the loss of the starch but to a general injurious action upon the plant. This was even more true of those experiments in which the starch providing portions were removed by means of the cutting out. Very recently a new investigator, Clara Vollikofer, has described a method for the removal of the starch of geotropically sensitive organs, which completely avoid any injury to the plants. She accomplished this by first cultivating embryo plants in the light for not too long a time, under normal conditions and, then placing them in the dark for a few days, thus causing the statolithic starch grains to disappear before the capacity for growth was exhausted. She employed for her studies embryos of the *Compositæ*, especially *Tagetes erecta* and *Dimorphotheca aurantiaca*, since in both of these the starch sheath of the hypocotyledons contains very little starch to begin with. The plants were allowed to grow in the light from two to four days and then were placed in the dark. After the lapse of one or two days a marked diminution of starch grains with respect to both number and size became evident, while after the lapse of three or four days embryos of Tagetes Dimorphothrea and Calembula (the latter after a partial removal of the cotyledons) had entirely lost their starch. Embryos of the Helianthus lost their starch at the end of five or six days, but in the case of these plants it was necessary to entirely remove the cotyledons because of their very high content of starch. Since the plants were first raised in the light they exhibited very slight appearances of etiolation or even none at all. In order to measure the amount of growth during the period of geotropic stimulation India ink marks were placed beneath the cotyledons; furthermore, in order to indicate with precision extremely slight twistings very fine glass pins were attached to the upper end of the hypo-cotyledon by means of a drop of plaster of paris. After such a preparation the

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plants which had been more or less deprived of their starch by this method were placed in a horizontal position for twenty-four hours, in order to determine whether they had retained or lost their capacity for geotropic twistings.

The results showed a close agreement between the content of starch and the appearance of geotropic twistings. Out of 397 Tagetes seedlings 48 showed geotropic twistings; 42 of these still contained statolithic starch grains, whereas in the remaining six examples no residue of starch could be found. The other 349 plants had lost their power of making geotropic curves although 271 of these exhibited considerable growth and, therefore, would have been able to make the geotropic curves had they received the proper stimulus. Expressed in percentages only 1.5 per cent of the seedlings as we see failed to correspond with the requirements of the theory. In the case of the *Dimorphotheca* in which scarcely a trace of starch was left, only three out of 201 plants displayed the geotropic curves and two of these did so without any perceptible starch grains. In the *Helianthus annuus and Calendula, Officinalis* this error amounted to only 1.2 per cent, while it was lacking entirely in *Helianthus multiflorus*.

In order to find out whether even this process was not slightly injurious some of the plants were brought again to the light, after being in the dark. In the Tagetes half of them exhibited reaction within 36 hours while in 48 hours all the plants were again strongly geotropic. At the same time the statolithic starch in the sheath had been regenerated. The same result was obtained in the *Dimorphotheca* in 3 or 4 days. The *Helianthus* seedlings which had been robbed of their cotyledon were naturally unable to recover merely through restoration to the light, but numbers of them succeeded in regenerating a part of their starch when they received a special food in form of grape sugar. Such plants as a rule also proceeded to execute feeble geotropic movments.

Sensitiveness of the Plasma.—In order to test the sensitiveness of a plasma at the time of the loss of starch a number of test plants were also excited *phototropically* by being exposed to the light on only one side. In order to exclude the possibility of a new formation of starch the seedlings were placed during this illumination in air deprived of carbon dioxide. Of 189 Tagetes plant tested in this manner 36 ceased growing. Of the remaining 153, 148 clearly exhibited phototropic curves. Similar percentages were found in the cases of other plants. This clearly proves that the plants which have lost their starch are still quite capable of curving in response to excitation and that the plasma has retained its sensitiveness to excitation by light. But this makes it very probable that the failure of geotropic curve depends neither upon the capacity for reaction nor the non-sensitiveness of the plasma. It seems far more probable that this failure to react of the seedlings is due to the lack of another primary factor in the chain of stimuli, and nothing is more plausible than that it is the lack of the starch grains which is responsible and to regard these as the transmitters of pressure...

Less convincing than the foregoing are experiments of Zollikofer regarding the cotyledon sheaths of grasses. These organs possess as we have said an abundant supply of movable starch grains in their points which are extremely sensitive geotropically. Fraulein Zollikofer found that these starch grains disappear at approximately the same rate that the geotropic power of curving vanishes. Since, however, on the one hand the breaking up of the starch is far from complete, while on the other hand a new factor makes its appearance in the piercing of the sheath by the young foliage leaves the relation between the two things is here hardly so clear.

Fraulein Zollikofer also discusses a theory proposed some years ago (1907) by Linsbauer, in a study concerning the growth and the geotropism of the aroid air roots. He tried to prove that it was possible for geoperception to be exhibited without any means of pressure transference. He had the idea that in the plasma itself netlike structures might undergo, under influence of gravity, alterations of form or at least of tension and that in this manner the plant might possess a perception of the stimulus of gravity. It can be admitted at once that such a concept is entirely supportable but it has the disadvantage *a priori* that it is incapable of observation and probably also of being tested by experiment. Fr. Zollikofer is quite right in laying stress further on the fact that the latest researches concerning the so-called *foam* structure of protoplasm regard such a network as consisting of a foam produced by two fluids which are non-mixable or only slightly so, and that such a foam must be regarded as possessing a comparatively stable structure by reason of its foam tension; a structure thus stable could hardly be altered by a mere change of position of the organ.

"TRAVELING" TIME

Let us now examine into whether and how far experiments with geotrophism support the statolithic theory. The time required for the change of place of the starch grains in the cells (the so-called "traveling" time) amounts usually to from 5 to 20 minutes. This agrees quite nearly with the fact that the briefest time during which a plant must be excited in order subsequently to accomplish even one curve (the so-called "presentation time") is about equal in length. But Fitting has shown that plants also perceive stimuli of less than one second's duration. This has been proved by the fact that it is possible to produce a geotropic curve by the cumulative result of such brief stimuli. Fitting also discovered that plants which are subjected to the geotropic stimulus alternately on different sides—for instance, they may be placed in a horizontal position and then after a revolution of 180° exposed in a smaller or greater angle of inclination constantly occur in the direction of the horizontal stimulus. This results again from the cumulation of the separate stimuli and this cumulative result is obtained even when the separate times of exposure are extremely short. In this and other instances the curving is supposed to occur without a gathering to one side of the starch grain. L. Jost, furthermore, observed curves in the roots and cotyledon sheaths of lentil plants which had been subjected for two or three hours to the effect of a centrifugal force amounting to 0.02-0.05 gr. without any one-sided assembling of the starch grains having appeared.

In 1918 J. Buder published his researches upon the statolithic hypothesis during which he made a precise test of the distribution of the starch under similar experimental conditions. These studies led to results essentially more favorable to the support of the statolithic theory. On the one hand he proved that there is a "traveling" or change of the starch which takes place by the combination of various angles of deviation and, furthermore, he proved that even when there was a very feeble centrifugal force applied (about 0.13 gr.) a one-sided settling of the starch occurred. In a case of slight application of centrifugal force the starch grains distributed themselves pretty evenly upon all the cell walls. Finally he found that the presentation times where there is such a slight degree of excitation increase in length in the same proportion as the traveling times of a starch grain. Furthermore, about this time Haberlandt had succeeded in giving a wider scope to the statolithic theory. He had come to regard the change of position of the starch grains no longer as a positively necessary condition for the production of a perception, but had come to the conclusion that under certain circumstances, even a one-sided pressure of the starch grains might produce a stimulus. When, then, the starch is evenly distributed over all the cell walls, as in Jost's experiments, "Then in consequence of the effect of the centrifugal force only those grains of starch are capable of exerting a pressure upon the plasma skin which are located upon the external cell walls, *i.e.*, those which are turned toward the periphery of the plane of rotation." Consequently the curve of excitation follows this direction.

Furthermore, if we change an organ from the vertical position in which position the starch grains are located upon the

lower transverse walls of the cells to the horizontal position, then it will immediately happen that there will be a pressure upon the formerly vertical but now horizontal cell walls by exactly those grains which press laterally upon them.

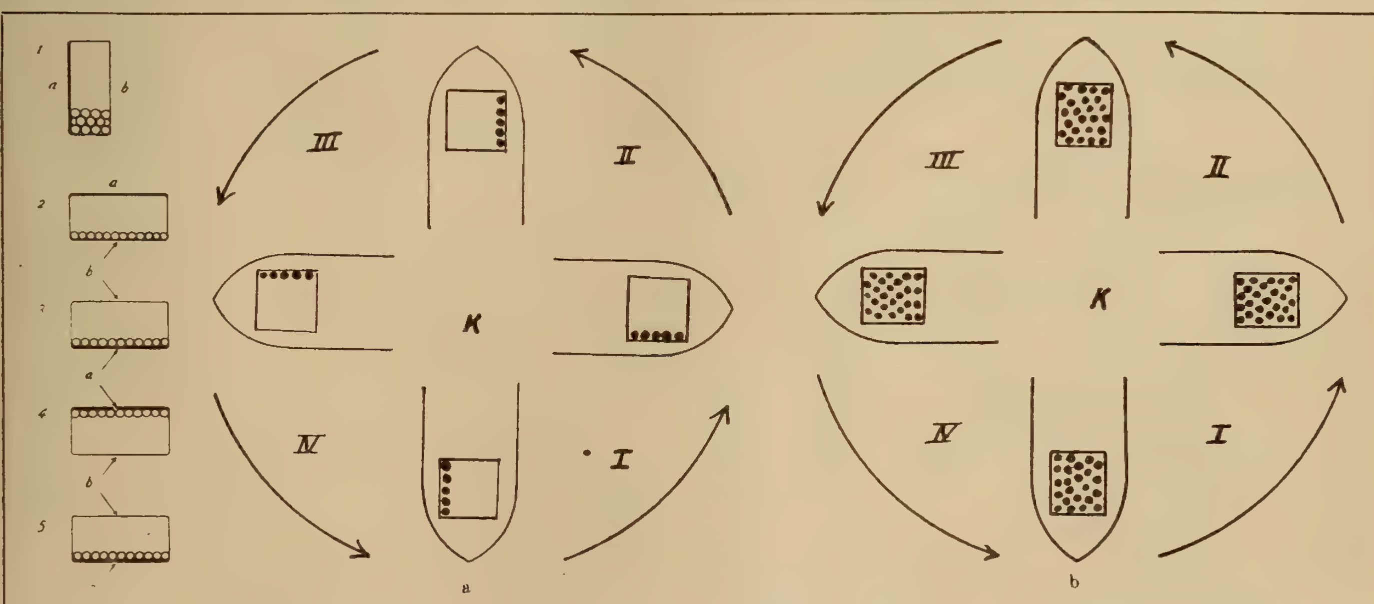
However, when Fitting suggests that the power of the starch grains to change their location is of no consequence so far as the statolithic theory is concerned because of the fact that it is admitted that a mere alteration of the direction of pressure is capable of producing a perception of the stimulus, he goes decidedly too far. An absolute condition for the production of the perception is a certain amount of deformation of the plasma, and such a deformation can naturally be far more readily produced by movable than by immovable particles of starch, and this, too, even when there is no change of position but merely an alteration of the direction of pressure.

As Fitting has shown experimentally the geotropic excitation in the various positions of inclination, alters with the sine of the angle of deviation from the vertical. Consequently the horizontal position is the optimum position for the geotrophic stimulus—and the horizontal position must likewise be the optimum position according to the statolithic theory, by reason of the fact that in the horizontally laid organs all the grains of starch lie next to the lower longitudinal walls. In an oblique position the magnitude of the portion of the wall covered for the time being with starch grains, depends likewise upon the sine of the angle of inclination. This holds good, of course, only in case of a complete change of position of the starch grains.

Buder has also suggested a new way for putting the statolithic theory to the test. He endeavored to create such conditions that the correctness of the theory might be proved not by the lack of geotropic twisting—as in the case of the depredation of starch—but on the contrary *by the very fact of the production of geotropic curves.* For this purpose he laid the roots of the cress plant in a horizontal position for 12 minutes, the time required to distribute the starch grains in an even layer over the now horizontal longitudinal cell walls. The roots were then rotated through 180°, so that the starch-covered walls were uppermost instead of underneath. In this position the roots were again allowed to remain for 12 minutes, during which period of time the starch grains sank to the opposite walls. Such roots have, therefore, starch grains assembled on one side but no impulse to twist since they have been stimulated upon exactly opposite sides for an equal length of time. In this instance the two stimuli balance or "compensate" each other. But it is possible to expose such plants in such a manner that first the longitudinal wall covered with starch grains is at the bottom and then the starchless longitudinal wall, an arrangement which is at once obvious in the diagram in Fig. 1.

If the statolithic theory is correct then curving must occur in the direction of the position in which the starch grains press upon the longitudinal cell wall. Otherwise, there would be no geotropic curves since from a purely physical standpoint both sides have been exposed to the same stimulus for an equal length of time. It was necessary, naturally to make the separate exposures so brief that while they lasted it was impossible for the starch grains to change their positions afresh. Buder obtained positive results from this experiment, since the roots curved in the direction indicated above thus according in their behavior with the requirements of the theory. The correctness of this theory was combated by Zielinski (1911), but a comparison of the work of the two men is convincing as to the correctness of Buder's views.

Buder's experiment was cleverly modified in 1914 by E. Richter, who observed that in the horizontally placed lentil roots the change of place of the starch grains began as a rule before the end of a presentation period and that, therefore, such roots do not curve after the change of position is accomplished. Roots previously thus treated were then slowly rotated about a horizontal axis in such a manner that the walls covered with starch grains were oriented in a perpendicular direction to the plane of location (Fig. 2a). When this was done the starch grains exerted a constant pressure upon the walls where they were accumulated, provided such walls, of course, were situated underneath during the rotation. It was found that here, too, 48 per cent of the 400 hard roots thus treated displayed the geotropic curve. But it is also possible to rotate the roots in such a manner that the starch-covered walls are parallel to the plane of rotation as in Fig. 2b. In this case the starch grains were generally unable to exert any pressure upon the plasma skin next which they lay and only 20 per cent of roots thus rotated formed the geotropic curve. That any such curving occurred is explained by Richter by saying that the roots in question were already stimulated during the horizontal exposure for a somewhat longer time than the presentation period. The results of these two experiments find a simple explanation in the statolithic theory whereas if that be rejected they become entirely



FIGS. 1 AND 2. DISTRIBUTION OF STARCH GRAINS UNDER THE INFLUENCE OF GRAVITY AND OF CENTRIFUGAL FORCE

Fig. 1 shows a cell of the root of the *Lepidium sativum; a, b,* opposite walls of cell. *1,* Position at start; *2,* distribution of grains after lying in horizontal position 12 minutes; *3,* same after being turned 180° and lying at rest 12 minutes; *4* and *5,* position of grains after stimulus every 10 seconds. Fig. 2 shows a cell of the root of the *Linum usitatissimus* according to Richter's experiments; *k,* axis of rotation perpendicular to plane of picture.

incomprehensible. G. and F. Weber raised objections to the statolithic theory in an article published in 1917. In their view the effect of gravity upon the viscosity of the plasma can be perceived. It is clearly true that the velocity with which the starch grains fall depends upon the degree of viscosity of the plasma. Heilbronn has devised a method by which the sinking of the starch grains can be directly observed and their velocity precisely determined. Delicate lamellae are cut from sprouting embryos; these are thin enough to be observed under the microscope but thick enough to contain portions of the starch sheath entirely intact. . . . Thus observed the starch grains are seen not to begin their descent until from ¼ to ½ hour has elapsed, since the plasma reacts to the shock of the wound by becoming perfectly rigid. Using this method G. and F. Weber found that the velocity of the fall was greater when the lamellae received a previous geotropic stimulus by being placed in a horizontal position, or, when there was a stimulation on all sides by a uniform rotation about a horizontal axis. From this and other experiments they came to the conclusion that since the alteration of the viscosity begins before the starch grains have made their change of position, the latter is without significance. We shall not here go further into their experiments since Clara Zollikoffer proved in the exhaustive experiments whose results were published by her in 1918, that the individual differences in the velocity of the fall in the separate cells are so great that it is impossible to make any exact comparison between the behavior of stimulated and of unstimulated cells.

CONCLUSIONS

In conclusion we may mention a still newer experimental message which can be employed for testing the statolithic theory, namely, the Piccard rotation experiment. Darwin first proved that only the extreme point of the root is sensitive to the stimulus of gravity. Similarly, Rotherts has shown that the points of the cotyledon sheaths of grasses are much more highly sensitive to the geotrophic stimulus than the lower portions of these organs. But Nemee found large quantities of movable starch grains in both the root tips and the sheath tips. . . . Piccard conceived the idea of stimulating the base and the tip of the root at the same time in opposite directions by means of centrifugation. This can be done when a root is so attached to an axle rotating rapidly in a horizontal plane, that its tip and the rest of it are found upon opposite sides of the axis of rotation. For a geotrophic curve to be accomplished in such a case, it is necessary for the whole organ to be oriented obliquely to the rotating axis. For this purpose I designed an improved form of the Piccard rotation apparatus. The object of experiment was a cotyledon sheath of an oat plant (coleoptile).

By means of this method Haberlandt showed that the root tip is indeed predominantly sensitive, but by no means exclusively so. If, for example, in the root of a bean plant the extreme 1.5-2 mm. of the tip rise above the axis, there follows a curving of the root away from the axis, *i.e.*, in the direction of the centrifugal force acting upon the tip, in spite of the fact that the zone of growth in which the curvation is mainly accomplished, lies upon the opposite side and is, therefore, excited in the opposite direction. If, on the contrary, only 1 mm. of the tip rises there follows a curving toward the axis, *i.e.*, in the direction of the base of the root. This proves that the latter also possesses a certain degree of sensitiveness which is much less, however, than that of the root. These facts are readily understood when we recall that the base of the root is at a much greater distance from the axis of rotation and is accordingly subject to a much greater degree of centrifugal force. Immediately behind the cap of the root containing the movable starch grain lies the vegetative point of the root, the transverse meristem which forms the cell material for the construction of the root. Since this zone is always found upon the side which decides the direction of the curve, Jost has been led to believe that the seat of the sensitiveness may lie in this meristem. . . . My own experiments, however, indicate that this is quite erroneous. Numerous experiments with various grass seedlings I found that there is indubitably a much greater geotropic sensibility of the point than of the base. In the oat plant, for example, the last 3 mm. of the tip decided the direction of the curve although the whole coleoptiles being studied were from 20 to 30 mm. long, so that the basic portion was subject to a considerably greater degree of centrifugal force.

SUMMARY

Summing up the whole matter the countless experiments made during recent years with respect to the geotropic behavior of the plants can be best explained, in my view, by the statolithic theory, and we are entirely justified in confidently accepting it at any rate so long as nothing better is offered in its place.

THE VISCOSITY VALUES OF PROTOPLASM

IN *The Botanical Gazette* for November, 1920, Dr. William Seifriz of Johns Hopkins University presents the results of studies made on the Viscosity Values of Protoplasm as determined by Microdissection.

In the author's work the method used has been that of microdissection. The instrument employed in this method is a modification of the Barber pipette holder. It consists essentially of two needle holders, each capable of three movements. The holders are fastened to the microscopic stage, and the two needles held in them project into a glass moist chamber in which the material to be worked upon is suspended in a hanging drop of water on the under side of a cover slip which forms the roof of the chamber. The needles are of glass and possess exceedingly fine but rigid tips.

The author's studies are based upon the examination of a considerable variety of material. Consequently, his conclusions may be regarded as rather generally applicable.

The results are summarized as follows:

1. Protoplasm is a polyphase emulsoid system.
2. Physical structure and not viscosity determines the sol or gel state of an emulsion. Consequently, while protoplasm undoubtedly exists sometimes as a sol and sometimes as a gel, yet sol and gel as descriptive terms of the physical state of protoplasm must be used with great caution when viscosity is the only criterion.
3. The viscosity of protoplasm ranges from a degree slightly more than that of water to the firmness of a fairly rigid gel.
4. While a certain degree of viscosity may characterize the protoplasm as a whole, the latter is always more or less divided into regions, whether larger general protoplasmic regions such as ectoplasm and endoplasm, or smaller localized centers of protoplasmic activity such as nucleus and chromatophores, which differ in viscosity from the protoplasm as a whole.
5. Some protoplasmic regions do not noticeably vary in their consistency, but the viscosity of a protoplast as a whole generally varies considerably within a rather wide range.
6. Some of the factors influencing changes in protoplasmic consistency are periodic changes in physiological activity, development, reproduction, mitosis, injury and death.
7. Streaming protoplasm is less viscous than quiescent protoplasm.
8. Young, active protoplasm increases in viscosity as it matures and becomes less active.
9. During mitosis there are very marked regional changes in viscosity.
10. Physical disturbance usually causes a pronounced increase in viscosity, although the rate of increase varies greatly in different individuals.
11. At death protoplasm frequently becomes temporarily very dilute, probably the result of excessive imbibition. Ultimately the degenerate protoplasm coagulates into a solid granular mass, if rapid dissolution has not preceded coagulation.

Snow as a Fertilizer

The Influence of Snow Upon the Development of Spring Vegetation

By M. Peyriguey Jacques

The French peasants have a pithy proverb to the effect that a snowfall in February is worth a pile of manure. This empirical bit of wisdom has recently been pronounced accurate by an agricultural meteorologist at Montpellier, M. Peyriguey Jacques, who has made a careful study of the matter. We give below a brief account of his observations for which we are indebted to La Nature (Paris), for April 17, 1920.—The Editor.

AT Mont-Aigoual in the northern Cevennes (Gard), the ground was covered with snow during the period of 187 days of the meteorological year, 1916, 172 days of which were consecutive; the snow thus provided the ground and the vegetation throughout the winter and the spring with a thermic screen protecting them against frost.

Furthermore, the snow thawed slowly enough to enable the ground and the plants upon it to profit by the addition of nitric acid and of ammoniacal nitrogen thus provided. This provision of nitrogenous matter together wtih the action of the first rays of the sun thus gave rise to an immediate sprouting and a *very rapid* development of vegetation, whose effects are entirely comparable to those obtained in agriculture by the supplying of *nitrates* in the spring. I observed in May particularly the *budding and the complete leafing of beeches during a period of five days.*

a. *Thermic Effects.*—The temperatures of the snow and of the air were obtained by means of dry thermometers; they were recorded at a depth of 0.10 m. and 0.20 m. in the snow and at a height of 0.20 m. above the surface of the snow; these observations were made from February to May, inclusively.

The following table shows the average monthly temperatures in ten-day periods of the snow and of the air, from the first of February to the first of May. We have omitted the May temperatures from the table, by reason of the thawing mentioned above, the temperature of the snow remained constantly at the freezing point (zero degrees cent.):

Periods	February	March	April
	At 0.20 m.	above the	ground
First decade	— 4.6	— 5.0	5.0
Second decade	— 1.3	1.4	— 9.4
Third decade	— 2.8	1.3	7.0
Daily average	— 2.9	— 0.8	3.9
	At a depth	of 0.10 m.	in the snow
First decade	— 2.2	— 4.1	0.0
Second decade	— 1.1	— 1.2	— 0.5
Third decade	— 2.3	— 0.6	— 0.1
Daily average	— 1.8	— 2.0	— 0.2
	At a depth	of 0.20 m.	in the snow
First decade	— 2.2	— 4.0	0.0
Second decade	— 1.3	— 1.2	— 0.5
Third decade	— 2.1	— 0.4	— 0.1
Daily average	— 1.8	— 1.8	— 0.2

It results from this that the variation of the average temperature of this thermic screen is nil during the months of February and of March at a depth of 0.20 m. in the snow; at a depth of 0.10 m. in the snow this variation is 0.2 degrees cent.; and at 0.20 m. above the surface of the snow it is 2.1 degrees cent. During the first and third decades of April the variation is nil in the snow, being almost constant during the second decade; the temperature of the air is very variable throughout this whole period.

The accompanying diagram shows that the variations of temperature in the air are much more important than those in the snow, and that the amplitude of these temperatures is as follows:

In the snow	Above the snow
Feb., 5.1 deg. cent.	Feb., 11.5 deg. cent.
March, 7.4	March, 16.4
April, 0.3	April, 21.8

The figures of the tables given above can be compared at a glance, and immediately demonstrate the efficacy of the snow screen as a protection against frost.

b. *Calculation of the Quantities of Nitric and of Ammoniacal Nitrogen Yielded by the Melting of the Snow or by the Rain.*—Snow is always richer in nitric acid than is rain, whereas the proportion of ammonia in rain water is always greater than that of nitric acid. Snow is likewise richer than rain in ammonia.

At the observatory of Montsouris the average amount of nitric acid from 1880 to 1894 yielded by rain water or by the

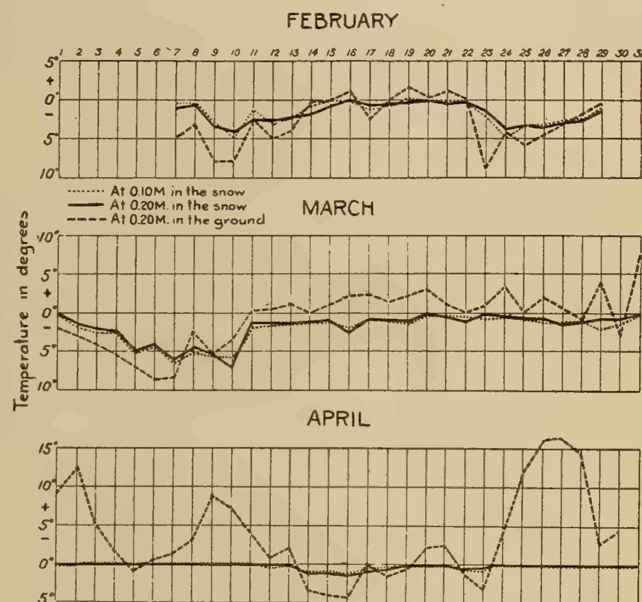


FIG. 1. DIAGRAM INDICATING VARIATIONS OF TEMPERATURE IN THE AIR AND IN THE SNOW AT DIFFERENT DEPTHS

melting of snow was 400 mg. of acid per square meter per year, or 4 kg. per hectare. Likewise at Montsouris M. Albert Levy found that the quantity of ammoniacal nitrogen deposited by rain or snow upon the park, for an average period of 20 years (1876-1895), was 1.086 gr. per year per square meter, or 10.860 kg. per hectare of ammoniacal nitrogen.

But since my own studies covered only a single period of snow I took the figures of the Montsouris observatory, which are almost identical with those obtained by me, and thus obtained, as the total deposit of nitrogenous compounds furnished to the ground and to vegetation by the melting of the snow and by the rain, and with an average precipitation of water of 551 mm. of water per year, 0.400 gr. as the average quantity of nitric nitrogen per square meter of the surface and 1.086 gr. as the average quantity of ammoniacal nitrogen per square meter of the surface. As these figures show, the ground at Montsouris was thus enriched by a total amount of nitrogen equal to 14.860 kg. per year per hectare.

For Mont-Aigoual we find for a period of six months (December to May, inclusive), and for a depth of rain water or of melted snow equaling 1621.7 mm., that the ground is enriched by 43, 736 kg. per hectare of nitrogenous compounds.

VARIOUS PHASES IN THE MANUFACTURE OF BILLIARD BALLS

Making Billiard Balls from Ivory

The High Degree of Skill Required, and Some of the Valuable By-Products

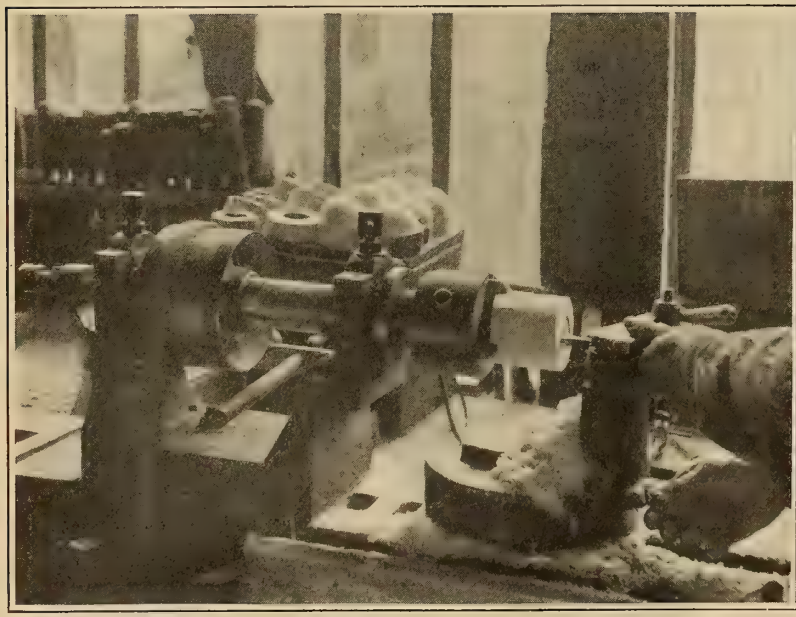
By T. A. Marchmay

ONE of the most beautiful of all natural materials both in color and in texture is the ivory of which the tusks of the elephants and other great pachyderms are formed. This has been universally recognized for centuries, not only among the Greeks and other civilized peoples of antiquity but among savage tribes. One of the most interesting exhibits at the American Museum of Natural History in this city, for example, is the remarkable collection of carved ivory figures brought by Mr. Lang from the heart of the African jungle, where they formed the treasures of a king, while to complete the picture, the great Phidias himself employed ivory as one of the most fitting materials obtainable to enshrine those visions of beauty with which he endowed mankind.

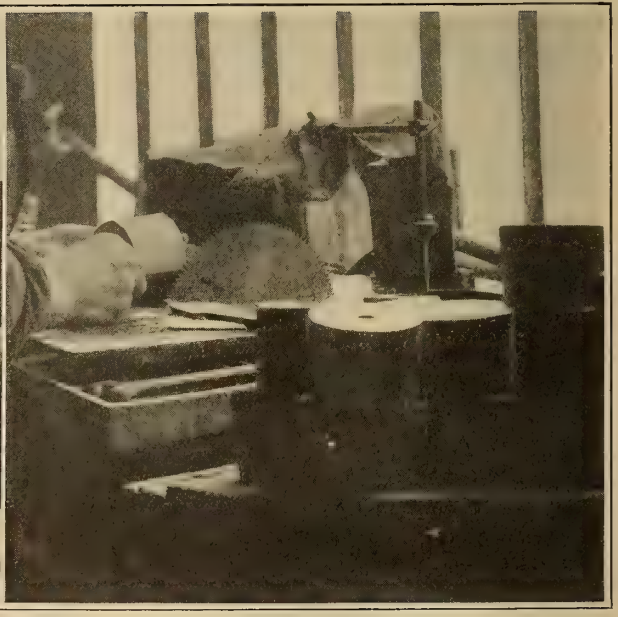
But ivory has certain physical properties besides its color and texture which make it eminently fitted for the construction of certain objects other than works of art. Chief among these properties is its elasticity and it is this which makes it *par excellence* an appropriate substance for the manufacture of billiard balls, since these are subject to constant shock and must instantly rebound to properly fulfil their function. Another quality of ivory, making it suitable for this purpose is the comparative ease with which it is worked. A billiard ball, for example, in order to be "true" must be absolutely spherical, since the slightest deviation at any point from perfection of curve would render it liable to deviate from the course the sure eye and deft hand of the player cause it to follow.

A third quality of ivory which renders it valuable for this purpose is the readiness with which it acquires a high polish, since this, of course, tends to diminish friction, which might interfere with the velocity of the ball, or even with its pursuance of the path the player intends that it shall take.

It is evident from the foregoing remarks that the manufacture of these delicate implements of play is a highly specialized affair and it is the main object of this article to describe the processes involved. Ivory is merely a form of dentine, *i.e.*, the hard and bone-like substance of which the teeth of most mammals are composed. But it is exceptionally tough, elastic and uniform in texture because of the fineness and regularity of the minute channels, known as dentinal tubules, which radiate from the pulp cavity in the center of the tooth to the latter's outer surface. The most valuable ivory is that obtained from elephant's tusks, in which these tubules bend sharply at regular



THE IVORY BLOCK IN THE LATHE, THE BALL BEING TURNED IN THE BLOCK



TRIMMING AND SQUARING THE SURFACE OF THE IVORY BLOCK

TAKING THE FINISHING CUT

POLISHING THE SPHERE

and frequent intervals, so as to produce a characteristic pattern in the material. Female tusks are more valuable because they grow more slowly and are harder, tougher, and more elastic, as a result, with narrower annual rings of growth.

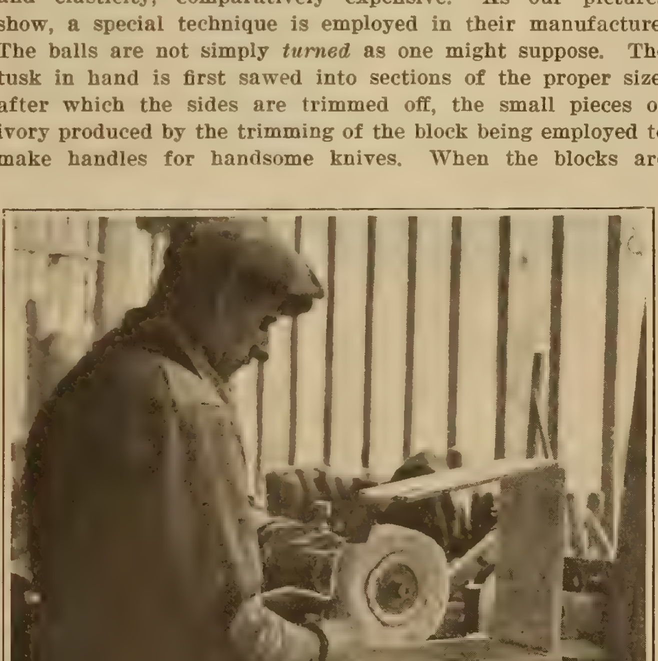
The best ivory comes from the African elephant, whose tusks are also larger than those of the Indian elephant, sometimes attaining a length of 9 feet and a weight of 160 pounds.

When first cut African ivory is semi-transparent and rather dark, becoming more opaque and lighter in color as it dries. In its natural state it is coated with a sort of cement, and when observed in cross section it exhibits not only the fine angular radiating lines described above, but also the "rings" which are concentric with the axis of the tooth, being arranged about a central grayish spot which represents the former pulp, now calcified. Ivory is richer in organic matter than most dentine, containing 40 per cent or more. The arrangement of the rings is due to the regular placing of minute cavities known as interglobular spaces.

At the present time ivory is extremely costly, the price of a tusk being from 4,000 to 5,000 francs. Since it is likewise one of the frailest and most easily injured materials which comes under the hand of the turner or the carver, it is evident that the workmen entrusted with it must possess both delicacy of touch and expert skill. It is said that there are only about 50 men in Paris engaged in the industry of making billiard balls in that city. In spite of the great care exercised by these skilled artisans, many accidents occur, especially since the finer and handsomer the ivory the greater the precaution necessary to protect it from heat, sunlight, currents of air, and other influences which may cause it to crack. Sometimes indeed, when the conditions appear to be perfect, a sudden explosive sound, like a pistol shot, is heard, and the operator sees the object under his hand split into two parts. Usually the crack, however, is very narrow, merely the thickness of a knife blade. While such cracks or splits gradually come together again, the object bears an ineffaceable scar, so that the artisan's work is lost. Other unpleasant surprises may be in store for the worker in this fragile material. Sometimes when the work is already quite far advanced a number of small yellow spots make their appearance; these indicate the presence of areas similar to the knots found in wood; the slang name for them in the trade is "beans." When these appear the material must likewise be cast aside. Again the tusk has sometimes been injured during the capture of the animal. Occasionally a bullet is found to have traversed the hollow of the tusk and buried itself in the heart of the latter where the most beautiful ivory is found. Here it produces a sort of caries which appears from point to point, sometimes extending around the heart throughout the whole length of the tusk.

MAKING BILLIARD BALLS

All these things serve to make the price of billiard balls, which as we have said must be perfect as to form, toughness, and elasticity, comparatively expensive. As our pictures show, a special technique is employed in their manufacture. The balls are not simply *turned* as one might suppose. The tusk in hand is first sawed into sections of the proper size, after which the sides are trimmed off, the small pieces of ivory produced by the trimming of the block being employed to make handles for handsome knives. When the blocks are



POLISHING IVORY BRACELETS

ready a foreman takes charge of them and draws upon the surface of the section by means of a metal template, a pencil mark which serves to indicate to the workman the line to follow in his work. The block is placed in the chuck of a lathe and by means of a curved tool of peculiar shape, called the *outil à ouvrir*, the ivory worker transforms one part of the block of ivory into a half sphere. Little by little the tool penetrates the bit of ivory which is rotated at high speed.

The workman then passes the block of ivory to one of his companions who turns it about and begins to accomplish the same work on the other side. In this way when the second man's work is finished a round ball of ivory, capable of rotating freely, has been cut from the original block. In order to extract this ball from its socket it is only necessary to saw the block circularly around the ball. The most difficult part of the manufacture has now been accomplished but before the final polish can be put upon the finshed ball, it must

A VALUABLE LOT OF ELEPHANT TUSKS TO BE MADE INTO IVORY BILLIARD BALLS

remain for six months in a drying apparatus. When properly dried it is placed in a socket in the lathe and polished by pressing against it a piece of cloth covered with a mixture of Spanish white and suet.

French balls are required to have a diameter of 25 to 68 mm. and Spanish balls of 68 to 74 mm., while those sent to the Philippines have diameters running as high as 80 mm. According to a French writer, Jacques Boyer, professional billiard players, insist upon having balls made from the ivory of the Indian elephant. They likewise demand balls which are perfectly centered and entirely free from the slightest flaw. At the present time a set of such balls costs from 800 to 1,000 francs in Paris.

Sometimes the blocks of ivory into which the tusks have been sawn, or even the block in which the balls have already been formed, are placed in the hands of a *tubeur* who sets them upon a sort of lathe and by means of a brass tube, with a toothed edge, saws them into rings which are later made into bracelets. These heavy and rather clumsy ivory bracelets are then sent to be carved in decorative designs, after which they are shipped to India to adorn the arms of native rajahs. Thus a bit of ivory may take quite a little journey in the world, being captured in the Congo, shipped to dealers in Belgium, from them to maufacturers in Paris, and from these to potentates of the Far East.

SOAP ANALYSES

THE fourth of a series of articles on guides to analyses which have been appearing in the *Chemical Bulletin* published by the Chicago section of the American Chemical Society, is devoted to the interpretation of soap analyses. The components of soap can be grouped under these headings: (1) The anhydrous soap which should be the principal ingredient and is the basis upon which soap should be bought or sold and evaluated; (2) the alkaline fillers which determine the suitability of soap for specific uses; thus a toilet soap should be practically free from uncombined alkali and for some industrial applications only the smallest quantity of free alkali can be tolerated. There are places, however, where a strongly alkaline soap is to be preferred; (3) the inert fillers indicate whether or not soap has been deliberately adulterated; and (4) special ingredients must me identified where special claims have been made for the soap. For example, the presence of a rather fine abrasive material would be an adulterant in laundry soap but one of the most valuable components is a scouring soap. The chemist must, therefore, not only be able to identify and possibly measure the quantity of a wide range of special components but must be thoroughly informed as to the uses of the soap before he can properly interpret its analyses; (5) moisture is usually determined in order to check up the complete analyses but is not of special importance; (6) the nature of the stock which has been used in the manufacture of the soap presents a problem which is often more difficult than the analyses itself. Rosin can be determined with a reasonable degree of accuracy, but its presence interferes in estimating the composition of the fats used especially if there be more than one which is usually the case. Added to all this are the aging problems for soap due to its nature which is subject to change due to oxidation and to reactions which, for example, cause free caustic to become converted to carbonate due to the absorption of carbon dioxide. Silicate of soda upon the absorption of carbon dioxide will decompose producing carbonate of soda and silicic acid which will, on analysis appear as an insoluble filler. Aging may also give rise to apparent high free acidity due to the oxidation of acids and this is usually accompanied by discoloration. This is particularly prevalent in chip soap where there is a maximum surface exposed.

It is apparent from the article that the analyses of soap and the proper interpretation of the data thus obtained is far from being a simple undertaking.

CAUSES OF SKIN SORES AND BOILS AMONG METAL WORKERS

THE research laboratory of E. F. Houghton and Company has brought together in the form of a pamphlet the results of investigation conducted early in the war on the subject indicated above which is the title of the publication. For many years there has existed a most serious problem in the metal cutting industries where there have been epidemics of sores and boils among the operatives. This was most frequently attributed to cutting oil although in some instances the liquid was actually a diluted soap. The trouble became serious in munition plants, hence the independent investigation of the subject which is now available in printed form. The company which financed the investigation and the publication of the report offers to send copies to those who are in a position to make good use of the information.

Friction and Lubrication*

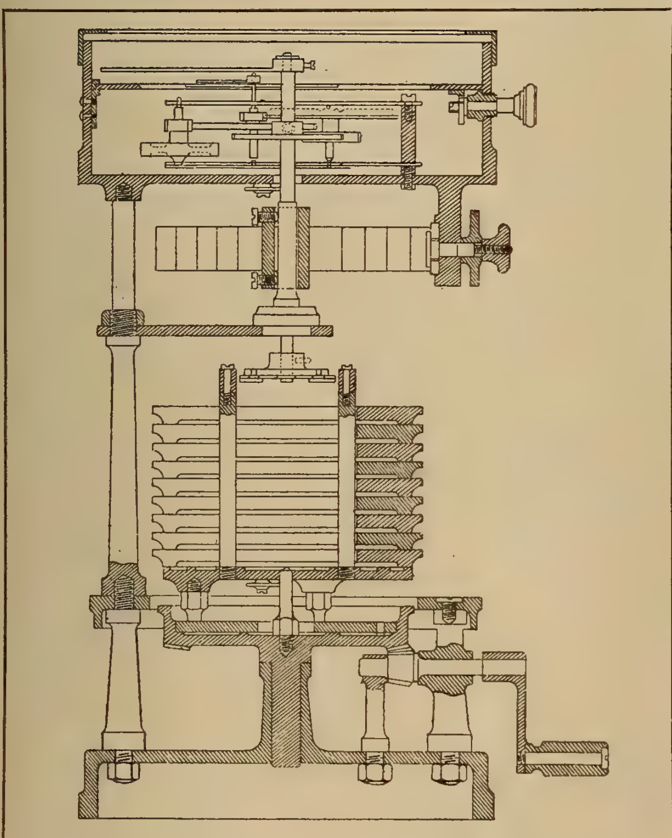
Is There a Chemical Combination Between the Molecules of the Metal and the Lubricant?

By R. Mountford Deeley

THOSE who have had to deal with the lubrication of machinery have found that the value of a liquid as a lubricant does not depend wholly upon its viscosity, for many moderately thick liquids will not prevent opposing metals from wearing and heating, while others will. We have thus come to regard oiliness as an important property of lubricants.

Under many conditions of work the opposing surfaces of machines are entirely separated by the lubricant, and our knowledge, so far as it goes, tends to show that the friction is almost, and often wholly, due to the viscosity of the lubricant. However, there are conditions of work during which such a thick oil film does not form and the oily surfaces touch each other.

The friction experiments now to be described were made under conditions which ensured that the surfaces should be in actual contact, and any differences in the frictional coefficients shown by the oils tested must have resulted from the contact of the oily metals, and not from the free molecules of the liquid itself.



MACHINE WITH WHICH THE OILS WERE TESTED

The experiments were made with a hand-driven machine easily manipulated. Three pegs, each 5/32 inch in diameter, rested upon the flat surface of a disc of metal which could be slowly rotated. These pegs were secured concentrically to an upper disc which could be weighted as desired and which actuated a spindle to which a spiral spring and recording finger were attached. When the lower disc was rotated the pegs were carried with it by friction until the surfaces slipped owing to the stress on the spring, and the finger then gave the value of the frictional stress reached. To damp the oscillations of the finger, the spindle to which the finger and spring were attached was geared to a small train of wheels, the freely revolving end wheel of the series having a weighted rim to increase its inertia. When measuring the static coefficient a pawl and ratchet were thrown into gear with the indicating finger to prevent it from moving toward zero if an oil film should form and the surfaces part. By very slowly moving the driving handle the finger was quickly brought to the position giving the static coefficient. The movable disc upon which the pegs rested lay in a circular dish, which could be filled with oil and slowly rotated.[1]

To ensure clean surfaces, or surfaces as clean as possible, the metals were ground in water with flour of carborundum. They were then polished with fine wet emery cloth, dried with clean blotting paper, and finally heated to get rid of all traces of moisture. The temperatures of the surfaces during the experiments varied from 16° to 18° cent.

Such clean surfaces are very sensitive to any contaminating agency. In one instance such a surface gave a momentary static friction coefficient of about 0.160. This surface was then breathed upon for about two seconds, and a further test gave a coefficient of 0.452, and it had to be repolished. Although the tests so far made showed that animal and vegetable oils largely displaced mineral oils from surfaces, mineral oils would not displace animal and vegetable lubricants.

Each friction value given in the tables to follow is the mean of five determinations at loads per square inch of 52 pounds, 43.3 pounds, 36.6 pounds, 26 pounds, and 17.3 pounds respectively.

The first experiments were made with mild steel upon cast iron and then with mild steel upon gun-metal.

Dry Surfaces.—Surfaces may be contaminated with oil and yet not be wet. The coefficient of friction—static—varies very much with the condition of polish of the surfaces, as well as with the nature of the contamination.

When the surfaces are properly ground and polished and no lubricant is used, the static coefficient becomes greater and greater as the surfaces continue to rub against each other. The initial static friction of a clean surface of mild steel resting upon cast iron was, in one instance, 0.154, and rose in the course of about ten minutes to 0.417, and was still rising when the experiment was stopped. A series of experiments was quickly made with surfaces of mild steel and cast iron, all quite clean. The results are shown in Table I. The surfaces during each experiment were worked upon each other as little as possible, so as to alter the condition of their surfaces as little as possible.

Table I—Mild Steel Upon Cast Iron

Load per sq. in. lb.	Static coefficient.	Kinetic coefficient.
52.0	0.167	0.175
43.4	0.173	0.188
34.6	0.184	0.197
26.6	0.204	0.204
17.3	0.213	0.223
8.6	0.230	0.229

*Reprinted from *The Engineer* (London), Jan. 21, 1921, p. 78. Preliminary report communicated to the Lubricants and Lubrication Inquiry Committee of the Department of Scientific and Industrial Research on December 5, 1918, and not hitherto published.

[1]Further details of Mr. Deeley's machine will be found in the Committee's recently issued final report, from which report our engraving is reproduced.

Lubricated Surfaces.—In the case of lubricated surfaces the procedure was as follows:

Clean surfaces were wetted with the lubricant, which was then wiped off, and the surfaces worked in contact for a time. When contact had taken place between the pegs and the disc below a dark streak was left; this was removed with clean dry blotting paper. The working of the surfaces together tended to smooth them, and it was found that the more this was done the more nearly the static and kinetic frictions approached each other. As the friction value thus obtained varied with the extent to which the surfaces were cleaned, no real value attaches to these results; but the test was considered useful, as it brought the rubbing surfaces into good condition. In Table II. some results obtained in this way are given.

Table II.—Rape Oil with Mild Steel on Cast Iron

Lbs.	
52.0	0.205
43.3	0.200
34.6	0.203
26.0	0.208
17.3	0.218
8.6	0.229

The static and kinetic coefficients were practically the same.

Surfaces prepared as above were then flooded with oil. In this condition, even when the speeds of rubbing were as low as 2 feet or 3 feet per minute, they separated and a thick oil film was generally formed. Under these conditions the coefficient of friction was much lower than when the surfaces were in contact. Sometimes, in the case of the kinetic coefficient, there was reason to suppose that the friction was partially due to the contact of the surfaces as well. Table III illustrates such a case.

Table III.—Mild Steel on Gun-Metal

Load, pounds	52.0	43.3	34.6	26.0	17.3	8.6
F.F.F. cylinder	0.052	0.058	0.067	0.081	0.100	0.172
Sperm	0.061	0.053	0.045	0.036	0.029	0.020

Here the kinetic coefficient of friction of the mineral oil decreases with increase of load; but in the case of sperm oil the coefficient increases with the increase of load. At the higher load the sperm oil film was being pressed out and every now and then the indicating finger gave a jump forward.

Table IV. shows the static coefficient and efficiencies of a number of oils tested between mild steel and cast iron and mild steel and gun-metal. The efficiency is—

100 — (static coefficient × 100) = efficiency.

Table IV

Lubricant	Mild steel on cast iron		Mild steel on gun metal	
	Static coefficient	Efficiency	Static coefficient	Efficiency
Clock oil	0.271	72.9	0.275	72.5
Bayonne	0.213	78.7	0.234	76.6
Typewriter	0.211	78.9	0.294	70.6
Victory red	0.196	80.5	0.246	75.4
F.F.F. cylinder	0.193	80.7	0.236	76.4
Manchester spindle	0.183	81.7	0.262	73.8
Castor	0.153	84.7	0.169	83.1
Sperm	0.127	87.3	0.189	81.1
Trotter	0.123	87.7	0.152	84.8
Olive	0.119	88.1	0.196	80.4
Rape	0.119	88.1	0.136	86.4

There is a marked difference between the friction of the various oils when the mild steel is opposed by cast iron and gun-metal respectively. Rape and olive give the best results and mineral oils the worst, castor coming between the mineral lubricants and the rest. Rape and olive are of equal value between mild steel and cast iron, but rape is the better between mild steel and gun-metal.

The value of such a test as an indication of the lubricating value of an oil depends entirely upon the mode of preparing the surfaces; for very irregular results are obtained if care be not taken in this respect. With greater experience better methods may be devised. Indeed, more recent experiments have shown that even more reliable results may be arrived at. It was found that unless the water be all driven off the surfaces by heating them well, contradictory results were obtained. However, the figures given in Table IV. are probably of the proper order of magnitude in each case.

Theoretical.—The coefficients of friction given in Table IV. make it clear that the static friction varies not only with the lubricant, but also with the metals in contact, and that oiliness is rather an effect produced by the lubricant upon the surfaces than a property of the lubricant as a liquid.

When the skin of a metallic surface has been removed by a file the file cuts the metal more easily, but if such a clean surface of metal be slightly oiled, or even if the hand be rubbed over it, the file will not cut anything like so easily. Thin films of matter of this kind cannot be wiped off. It is necessary to grind the surface in water, when the water readily wets the surface and it is easily abraded.

Oily liquids would appear to be those the molecules of which readily and firmly enter into combination with the molecules of the metallic surface. The combination appears to be not merely with the molecules at the surface, for it is necessary to remove a comparatively thick crust before clean metal is reached. Roberts Austin[2] remarks: "The continuation of these experiments has led to the recognition of the remarkable fact that diffusion of metals can be readily measured, not only in the molten state, but in solid metals. It is certainly remarkable that gold, placed on the bottom of a cylinder of lead 3 inches high and heated to only 200° C. or 400° F., which is far below its melting point, and while it is to all appearances solid will have diffused to the top in notable quantities by the end of three days . . ." It is possible that the molecules of a liquid lubricant, or those of a lubricating grease, penetrate the metal for some considerable distance in a similar way and form a comparatively thick film of a compound which acts as a lubricant.

Dunstan and Thole[3] remark: "It appears, then, that the true lubricant is an unsaturated compound, possessing all the attributes of such a compound, *i.e.*, (1) capacity to absorb iodine, bromine, oxygen, and so on; (2) solubility in strong sulphuric acid; (3) higher C/H ratio than the saturated derivative. Apparently the same facts hold good in relation to fatty lubricants. Rape oil, castor oil, and olive oil contain in their molecules double bonds, and are superior in body and viscosity to such a saturated product as, for example, tallow."

The unsaturated molecules of the lubricant seem to attach themselves to the molecules of the metals they wet, and form skins capable of preventing the "free" molecules of opposing metallic surfaces from adhering. If such be the case it is reasonable to suppose that the friction coefficient between such metallic skins would vary with the metals in contact as well as with the nature of the oil.

NEW STANDARD SAMPLES OF STEEL AND BRONZE

A new standard sample of electric steel No. 51, 1.2 per cent carbon, and a new standard sample of cast bronze No. 52 (approximate composition, copper 88 per cent, tin 8 per cent, zinc 2 per cent, lead 1.5 per cent, antimony 0.15 per cent, iron 0.10 per cent and nickel 0.10 per cent) have recently been prepared by the Bureau of Standards and are now ready for distribution with provisional certificates.

[2]Fourth report of the Alloys Research Committee, p. 58.

[3]*Journal* of the Institution of Petroleum Technologists, June, 1918, p. 205.

The Colloidal State of Matter

A Review of Recent Investigations in Colloidal Chemistry

By John J. Birch, Pd.B.

MATTER, as we understand the term, exists in three forms, namely: solids, liquids and gases. Until recent years it was believed that matter existed only in the crystalline state; but after critical investigation the crystalline theory of matter has been found inadequate to explain all its existing states, and consequently matter has been divided into two states: colloidal and crystalloidal. Investigations along three particular lines led to the assumption that it exists not only in the crystalline, but also in some other phase.

In 1827, Brown, the English biologist, studied the biological state of the motion of microscopic animalcules in liquids and found that infinitely small material particles in liquids possessed a similar characteristic motion. This has contributed important complements to the Kinetic Theory of matter and built up the hypothesis of the Brownian Movement. About 1850 English microscopists in their endeavor to increase the magnifying power of the microscope, in order to study the hypotheses of Brown, introduced the method of illumination, known as "dark background illumination."

The last line of investigation was the contribution which Faraday unknowingly made. One of his keen ambitions was to show experimentally the connection between electricity and light. In pursuance of this object, he sought to find the effect exerted on light by very fine particles of metal suspended in liquids. He prepared several solutions of silver and first suggested what is now believed to be the true constitution of these solutions.

A solution, as we understand the term, is the absorption of one body, by or into another, giving the characteristics of homogeneity, non-settling and minute subdivisions of the dissolved substance. They are generally defined as homogeneous mixtures, inasmuch as they never separate mechanically into components and are so completely dispersed that any solid particles cannot be recognized even by optical methods. The word is used for other systems than those containing a solid dissolved in a liquid. Liquids may be dissolved in liquids, as alcohol in water; and the absorption of nitrogen by iron takes place in accordance with the same laws as the solution of solids in liquids, and is just as true a solution. The absorption of liquids by solids and homogeneous mixtures of solids are perfectly familiar. The sapphire is a solution of a small amount of strongly colored substance in a large amount of colorless aluminum oxide. It may therefore be stated that solutions of gases, liquids and solids in liquids are possible, yet there exists no form of crystalloidal solution having the same properties and characteristics as the colloids. At the present time we do not speak of the differences between colloidal and crystalloidal matter; but only separate the colloidal from the crystalloidal states. The chemistry of colloidal therefore is the science of the colloidal state of matter.

COLLOIDS AND CRYSTALLOIDS

Although the nomenclature and scientific researches relative to colloids have been one of the more recent problems of chemistry; yet colloids existed and their peculiar properties were made use of by the ancient peoples. Substances in the colloidal state were employed in the early stages of human culture as adhesives and the Egyptians used such substances as starch and dextrin in dyeing. The Chinese allowed their clay and porcelain to decompose which increased colloidal substances in them and raised their degree of plasticity. The term "colloid," derived from the Greek (kolos) which meant to glue or that which was incapable of crystallizing, was proposed in 1861 by Thomas Graham. He used the name to designate those substances which were incapable of diffusing through porous membranes. Substances such as salt, hydroxides and mineral acids which diffuse readily through membranes were called "crystalloids." Recent investigations have shown that the colloidal condition is possible not only for a limited class of substances, but is in general, possible for many, if not all. One might define colloids then, as the condition of insoluble substances, in so far as ordinary observation and the common methods for separation of heterogeneous phases are concerned, as those forms of matter which exist in a non-crystalline state, remaining suspended in water and which pass unimpeded through filters. An extremely finely divided solid suspended in a liquid is the most common type of such mixtures. The most important substances in the colloidal state are starch, albumin, tannin, dextrin and gelatin.

Colloids were first thought to be difficultly soluble substances in solution. For many years the belief was prevalent among chemists that these liquids represented true solutions of difficultly soluble substances in the form of soluble modifications of the substances. Like ordinary solutions the liquids were found to show a certain osmotic pressure, but unlike ordinary solutions the osmotic pressure was very small in proportion to the quantity of substances present.

Substances	Concentration Per cent	Osmotic Pressure Cm. Mercury
Gum Arabic	1	6.9
Dextrin	1	16.6
As_2S_3	4	1.7
$Fe(OH)_3$	1.1	0.8

There were other chemists who considered the colloidal liquids to represent suspensions of minute solid particles in an extremely small state of subdivision. The correctness of this has been proven conclusively by observations made upon such solutions with the ultra-microscope. The colloidal solutions of gold are seen to contain minutely small particles of gold, the diameter of which ranges between 60 and 6 $\mu\mu$. The size of the particle likewise influences the color of the solution. There are still finer subdivisions the diameter of whose particles cannot be measured.

A large number of apparent solutions resembling true solutions even less closely than colloidal solutions. are known as crystalloidal suspensions. Several methods of preparing these have been worked out and applied. Colloidal suspensions of many of the metals also have been prepared by electrical means. If a dilute solution of a metal be electricalized, the metal is not deposited on the cathode; but the arc under the water, tears the metal from the cathode in a very fine state of subdivision and these remain suspended in the water, which in turn becomes discolored. It is then filtered to remove the larger particles. When a drop of this is placed under a powerful microscope, the fine state of subdivision can be seen. The particles in this suspension bear an electric charge which is shown by the fact that they move through the solution under the influence of the current.

ELECTRIFICATION OF COLLOIDS

One of the important discoveries made on colloids was the observation that the suspended particles of a great number of colloids bear an electric charge—thus creating a potential difference between the particles and the liquid in which they are suspended. The liquid holding the colloid in suspension seems to have control over this electrical charge. For example; colloidal platinum in water is negative; while in a mixture of alcohol and water, a positive charge is manifest. All

amphoteric colloids, or those which have acid and basic properties, change the character of their charge, when the liquid in which they are suspended is made to pass from an acid to an alkaline condition and vice versa. Silicic acid in the colloidal state, changes from negative to positive as the solution passes from a basic to an acid reaction. Albumen, which is likewise an amphoteric colloid, shows some change of charge in the colloidal condition, and the charge has been ascribed to the change of basic or acid functions.

The electrification of the colloid may result from what is known as contact or surface electricity. There is always a potential difference between the surface of two different substances. Then in the case of colloids, which are finely divided suspensions, the contact surfaces are enormous as compared with the surfaces involved in ordinary contact. The area of each particle, multiplied by the number of particles, would give a tremendous area. However, very little is known relative to contact electricity; but it has been conjectured that it does not differ from ionization. This fact remains yet to be fully established. Whether certain metals such as gold, platinum and silver owe their charge to contact effects, or to their tendency to ionize is not definitely known. Although the source of the electrification of colloids is as yet only a conjecture, still we can calculate the charge which each particle bears with a high degree of accuracy.

It would seem possible to calculate the charge on colloidal particles, by determining the conductivity of a colloidal solution of a metal prepared by sparking; for in such a solution the amount of foreign electrolyte would orlinarily be very small and any conductivity would necessarily be due to the transference of electricity by the particles themselves. The average charge per particle has been found to be 2,385 x 10^{-10} electric units, or 795 times that of the hydrogen ion. If the particles carry a negative charge, some positive ions must be present as well, for the colloidal solution as a whole remains unchanged. Calculations are made on this assumption, giving results inconsistent with those obtained by the use of Stokes' formula, assuming the mobility of the positive ion to be equal or less than that by the hydrogen ion. This is the same as to say that the positive and negative ions are absorbed by the particles; both being in excess at different distances from the particle, and may serve to explain the movement of the particles. Probably the first method suggested for determining the size of the colloidal particle however, dependent upon the application of Stokes' law for the rate of fall of solid spheres, through a liquid medium. Assuming that a body be falling through air and that the only active force is gravitation; then by Newton's law the distance which the particle falls is expressed by the formula $D = \frac{1}{2} (a\ t)^2$. In the case of the colloidal particles, we have several different conditions. The forces of friction and the Brownian movement in the colloid itself are the added factors. According to Stokes' law, a sphere tends, after a short interval of time, to attain a limiting velocity, (v), such that the forces of friction exerted by the fluid is expressed in the equation $F = 6\ \pi\ nav$, where (n) is the coefficient of viscosity of the fluid and (a) the radius of the particle. For a steady motion, this force must necessarily be equal to the forces of gravity which act on the particle emersed in the fluid. The latter force is given by the equation $F = 4/3\ \pi\ a^3\ (p - p')g$, where (p) and (p') are densities of the material of the particles and of the fluid respectively. Equating these forces, we have:

$$\tfrac{4}{3}\ \pi\ a^3\ (p - p')g = 6\ \pi\ nav. \quad a^2 = \tfrac{9}{2} \times \frac{n\ v}{(p - p')g}$$

Particles which have a radius less than 10^{-5} cm. are overcome by the Brownian movement and settling of the colloidal particles is prevented, thus giving the formula a very narrow application for aqueous solutions. If there is a tendency to settle, the particle must first attain a limiting velocity, (v) corresponding to Stokes' formula: Weight $= mg = 6\ \pi\ nav$, where (mg) is the gravitation pull on the particle in water. An interval of time is required when the particle begins from rest and is accelerated under the forces of gravity. The smaller the particle the less the limiting velocity, and at the same time, the smaller the particle the greater will be the force of the Brownian movement caused by molecular shocks. When the Brownian movement is so large, that is to say, when the molecular shocks in various directions are so pronounced that the particles do not attain a limiting velocity in a downwise direction due to gravity, the particles do not show any disposition to settle.

THE BROWNIAN MOVEMENT

Before the time of Brown many microscopic objects suspended in water had been observed to be in rapid movement; but this phenomena was supposed to be connected with activities of living matter. Brown disproved this by furthering the experiments of Needham and Gleichen on the observation of the movement of the minute spherical pollen particles in a liquid. He examined the aged spore dust of mosses and equiseti in order to prove whether or not the motion was a phase of life. Finding that from these there was a lively motion, he examined inanimate substances as lead, bismuth, arsenic, sulfur, rocks, glass, coal, and gums finding the same movement in each. Brown suggested that the cause of the movement arose neither from currents in the fluid nor depended upon the movement of a fluid attending its evaporation. Guoy attributed this motion to thermal vibration of the molecules in the liquid. Ramsay and Cantoni believed the motion was related to the size of the particles and not to the material of which they were composed.

Ramsay believed that the velocity depended upon the size and density of the particles. It was his belief that the particles in pure water do not touch each other at any time, and that they do not exert an influence one upon another. This brings us to the invention of the ultra-microscope which has since made possible more thorough examination relative to the size and motion of the particles in the Brownian movement. This movement has many suggested causes. The motion is not due to the infusoria, for Brown found that the motion exists with inanimate objects, such as metals, rosin, glass, etc. The motion is not due to internal changes as mechanical vibrations from surrounding objects incident light and heat. Extensive researches on this hypothesis have been made by Wiener, Exner, Guay and Zsigmondy. The influence of gases surrounding the particles also does not cause this motion. Small bubbles of gas contained in a liquid enclosed in spaces in certain minerals, are in constant vibration and when the bubbles are below 0.002 mm. in diameter they are subject to a constant quivering motion. The motion in this case is caused by an incessant interchange between the molecules of vapor in the bubbles and those of the liquid which surrounds them. Evaporation of the liquid would not cause a motion, for when heat rays fall upon a solution they do not cause any pronounced change in the motion. Brown made extensive investigations from this standpoint. Also the influence of gravity, magnetic or electrical forces between the particles cannot explain the motion, for it has been found, almost invariably, that the addition of electrolytes stops the Brownian movement. Surface tension does not seem to be its source. Fuchs has formulated several laws relative to the part played by surface tension in deciding whether small particles will unite to form larger ones or still further subdivide. "If the molecules of the liquid are attracted more strongly by those of the solid, than they are by the molecules of the liquid when the molecules of the solid attract one another the potential energy will be a minimum when each particle of a solid is surrounded by a shell or liquid of a thickness equal to the radius of molecular forces. The two particles will then repel each other if brought closer than twice that distance. If either of the forces solid—solid or liquid—liquid is greater than the force solid—liquid the potential energy will be lessened when the two particles are made to approach as closely as possible. They will then attract each other."

That internal heat energy is the source or cause of the vibration seems to be the best theory. As the temperature rises the velocity increases and the viscosity of the dispersing medium decreases. Viscosity and temperature are dependent on each other for the viscosity of the medium is decreased with a rising temperature.

The Brownian movement exists in gases as well as in liquids. Ehrenhaft was the first to carry out direct measurements on the Brownian movement of particles in gases. He found that there was a much livelier movement in gases than in liquids and that the action of gravity in causing a vertical decent of the particles was also much more apparent in gases than in liquids. In the larger particles, found in the smoke of cigars and the fumes of ammonium chloride he found pronounced Brownian movement, while in the smaller particles obtained by an electric discharge between zinc, platinum or silver electrodes he found the motion very rapid. The measurements on cigar smoke particles gave a mean velocity of 2.5×10^{-3} cm/sec. while on the smaller particles of silver the mean velocity was 4.6×10^{-3} cm/sec. The following tables gives the velocities impressed by molecular shocks and by the force of gravitation respectively on silver particles of various sizes (density 10^{-5}) and shows that when we reach particles having diameters of the order of the wave length of light the two velocities do not differ materially; but in the smaller particles the velocity induced by gravity soon becomes negligible, while the particles increasing above 10^{-5} cm. the motion due to gravity is dominant.

Radius of the particle in cms.	Velocity in cms/sec. due to molecular shocks.	Velocity in cms/sec. due to gravity.
1×10^{-7}	6.3×10^{-3}	12×10^{-8}
5×10^{-7}	2.8×10^{-3}	3×10^{-6}
1×10^{-6}	2.0×10^{-3}	12×10^{-6}
1×10^{-5}	6.3×10^{-4}	12×10^{-4}
1×10^{-4}	2.0×10^{-4}	12×10^{-2}

Brownian Movement Velocities

Material	Diameter $\times 10^5$ cm.	Medium	Temperature	Velocity $\times 10^5$ cm/sec.
Gamboge, Quartz	10.0	H_2O	18°	23.0
Silicic acid, White lead	16.0	"	"	5.0
Sulphur	4.0	"	21°	38.0
Dust part.	2.0	"	—	0
Platinum	0.4	Aceton	18°	3900
Gold	0.06	H_2O	20°	700

The difficulties of direct observation was overcome by Henri who applied the cinematograph to the microscope. This shows that the particle oscillates in a haphazard fashion about a mean position during a short interval of time.

THEORIES OF COLLOIDS

There are four accepted theories relative to the formation of colloids. Many colloidal solutions prove themselves to be mechanically inseparable since they pass through filter paper even if slightly. Nevertheless the lack of homogeneity can be shown by the use of ultra-microscope and it is by this instrument that we have been able to study colloids with better results than was formerly possible. We know that liquids containing particles of 20 $\mu\mu$ (1 $\mu\mu = 10^{-6}$ mm. or 1 $\mu\mu = 0.000001$ mm.) appear clear, and that turbidity first issues, only when the particles of about 100 $\mu\mu$ in magnitude are present. The solution theory suggests that colloids have exceedingly large molecular weights. The osmotic pressure likewise is exceedingly small in proportion to the quantity of the substance present, being so small in many cases that it cannot be measured. Inasmuch as the osmotic pressure bears a ratio to the number of molecules this led to the assumption of a small number of molecules and therefore a very great weight to each. The following table lists the molecular weight of a number of common colloids.

Molecular Weights

Hydrogen	0.1×10^{-7} cm.	(Size)
Methyl Alcohol	0.5×10^{-7} "	"
Chloroform	0.8×10^{-7} "	"
Glycogen	1,625	
Ferric Hydrate	6,000	
Tungstic Acid	1,750	
Egg Albumen	14,000	
Starch	25,000	
Tannin	2,643-3,700	

The large molecules explain the lack of ability to pass through animal membranes, for the reason that the molecules are too large to pass through the partition pores; also the gel formations may be viewed as a meeting of the already large molecular complexes present, forming still larger microscopic aggregates which become visible. Colloidal particles have a marked tendency to cleave firmly to one another and to form bodies; a property which is very advantageous. In all colloids we see foam formation when the substances in the colloidal state, together with free alkali or free acid, are mechanically agitated; in the organic colloids in a marked way in soap and protein; and in inorganic colloids; in talcs, when they form silicon hydroxides in contact with water and dilute hydrochloric acid.

By the absorption theory a number of properties can be explained. According to that theory, sols are not ordinary solutions; but contain a phase of molecular complexity, distributed through the dispersing medium. This explains the essential deviation from the crystalloidal sols, that is to say, the absence of osmotic pressure, lack of diffusion and electric conductivity.

The suspension theory was perhaps the first view taken in reference to colloidal theory and has later been proven conclusively true. It assumes that minute particles are suspended in an extremely fine state of subdivision. Colloidal gold contains minute gold particles from 60 $\mu\mu$ to 6 μ in diameter There are solutions whose particles are too small to be measured, but by passing a beam of light through the solution the presence of turbidity can be observed, which proves conclusively that the solution contains something in suspension. The ultra microscope informs us only as to the presence of the particles in the colloidal solution, and does not enlighten us relative to the exact relations and conditions of the separate particles.

The crystalline theory, which is in reality only a furthering of the suspension theory, holds that the colloidal particles are crystalline. It assumes that the crystalline state is the only possible state for matter and accordingly solids, liquids and gases are crystalline. This has a substantial background for many optical properties separate the assumption of a crystalline phase, as for instance, the scattering of colloids in the ultra-microscopic image.

COLLOIDS IN BIOLOGY AND MEDICINE

Colloids and their properties are of special interest to the student of biology since the cells of all living organizations are made up of chemical substances known as protoplasm, the structure of which is due to colloids. The sun throws down heat on the green foliage of the leaves, decomposing the carbon dioxide into carbon and oxygen. The free oxygen is returned to the air in an unknown way and the carbon is worked up into substances in the colloidal state; especially to starch. The heat of combustion of starch to carbon dioxide in water amounts to 4,123 calories per gram, therefore the same amount of energy, by the laws of the thermodynamics, is necessary to form starch from carbon dioxide and water. Since the reduction of carbonic acid gas occurs in sun light, this radiant energy must have been furnished by the sun.

Colloidal solutions may be prepared which are only slowly influenced by a change in external conditions. The passage of a hydrosol into a hydrogel may be preceded for a long time by a metastable condition of the colloidal solution. The forms assumed by the depositions or growths from such slowly changing metastable colloidal solutions sometimes closely resemble the lowest form of living organisms. The metastable colloidal solutions may be prepared from ferric nitrate and sodium silicate in such proportions as to give a slight deposit after boiling for ten minutes. The solutions then contain two metastable colloids: ferric, hydroxide and silicic acid. On the other hand, those completely deposited do not form growths. The colloidal solution is then placed in sterilized tubes which after being hermetically sealed is heated in an autoclave for 15 minutes at 110 deg. C. Micrographs after 7 months showed growths in the tube which consisted of (1) particles sometimes fine and sometimes coarse granular deposits with fine fibers running in them. (2) Chains of dots sometimes slightly elongated. (3) Branching coarse fibers resembling cotton fibers. (4) Exceedingly fine fibrils sometimes forming a net work like a fibrine network. At other times they are single and convoluted into the most intricate knots or loops. When stained with methymlene blue dye, they do not give the reaction with iodine and sulphuric acid for cellulose. The living cell is built up of metastable colloids but nothing can be observed which can be described as a living organization arising from the inorganic solids and it was found impossible to subculture any of the growths in other media.

Colloidal chemistry is by no means a new subject. The properties of colloids have long been made use of, but only during recent years has work been done on colloids from a theoretical standpoint. The early Chinese potters knew something of colloidal properties, as shown by the manner in which they allowed their clay to "age" or become more plastic. The ancient Egyptians were skilled in the art of cement making, which far exceeds any work which has been done at the present. Their pyramids have withstood the elements for 5,000 years and are today many of them in excellent state of preservation.

The evolution of the photographic plate serves as a striking example of the use of gelatine and similar colloids in the arts and industry. In the very familiar operations involved in cooking, brewing and dairying, colloidal solutions are always appearing and operating under definite laws. It is probable that no other substances are more interesting from the colloidal standpoint than common clay. It is the mineral part of the soil, composed of rocky material and complex silicates containing iron, aluminum, calcium, carbon dioxide and the phosphates. In the manufacture of cements and porcelains, in the purification of water and in the treatment of various soils; colloidal properties come of the first importance. The setting of cement is thought to be due to the coagulation of the hydroxides of silicon, aluminum anl iron and the action of carbon dioxide in forming after a time, hardened calcium carbonate. The gravel acts only as neuclei about which the coagulation takes place. Many more examples could be cited to show the intimacy which colloids hold in our most familiar chemical problems, and it is a praiseworthy fact that at the present time so much time and study are being spent seeking after their hidden secrets.

BANISHING GERMS WITH A SILVER SPOON

RECENT investigators have established the fact that certain metals have a definite sterilization effect when present either in mere infinitesimal traces or possibly by some sort of transmitted effect. The celebrated botanist, Naegeli, was one of the first to prove this by the following experiment: A glass flask in which a few copper coins had previously been lined was filled with water after the removal of the money. After a short time a number of algae were observed clinging to the sides of the flask, but strange to say those portions of the glass against which the copper coins had rested remained entirely free from such a growth. When these portions of the surface were tested for copper with chemical agents, however, no trace of the metal was discovered. For this reason Naegeli assumed that this curious phenomenon was due to some hidden or latent power.

Quite recently, however, an Austrian physician, named Saxel, has repeated this experiment using silver instead of copper. He found that it was possible to completely sterilize water merely by placing a silver spoon in it; in fact a glass vessel once treated in this manner even retains its germicidal power. Yet not the slightest trace of dissolved silver was to be found in the water. For this reason Dr. Saxel came to the conclusion that the action in question cannot be ascribed to any known chemical or physical cause, but must depend upon some force capable of acting at a distance. Certain other investigators have discovered in the meanwhile that extremely slight traces of dissolved metal exert an inhibitive action upon the development of bacteria, for example, copper sulphate acts as a bactericide even when so dilute that the solution contains only one-fifty-millionth of the salt.

Another German scientist, Professor Bechhold, has recently pursued this matter and has described his results in *Umschau.* He was able to prove that glass vessels which had contained either nitrate of silver, calomel, or chloride of mercury, could not be used to grow germ cultures no matter how carefully washed, until they were boiled in nitric acid. His conclusion was to the effect that there is in general no such thing as a completely insoluble substance, but that in some cases our means of testing them are not sufficiently delicate to discover extremely minute quantities. To prove his point he performed a remarkable experiment, by means of which he succeeded in making visible to the eye the solubility of substances in spite of the fact that ordinary physical chemical means cannot detect such solubility. He began by forming cultures of staphylococcus upon agar-agar in vessels of hard glass. After the congelation of the agar-agar small disks of filter paper were placed upon it and a silver coin laid upon each disk. The filter paper was then coated with so-called insoluble silver compounds, such as sulphide of silver, iodide of silver, chloride of silver, oxide of silver, bromide of silver, silver chromate, silver carbonate and silver oxilate, this being done before the introduction of the disease germ. The staphyloccocus cultures were then kept in a dark room at the ordinary temperature for four days. This was in order to prevent the development of the bacteria at the same time that it gave an opportunity to allow the supposedly insoluble substances to become diffused in the agar-agar in case, as the experimenter suspected, there was really some slight capacity of being dissolved.

The culture vessels were then placed in an incubator and allowed to remain for twenty-four hours, whereupon their examination showed the following curious results. Not only surrounding the silver coins but also in the vicinity of the paper disks smeared with the so-called insoluble silver compond, there were spaces entirely free of bacteria, although all around these spaces the germs were growing luxuriant. The obvious deduction is that traces of the compounds had been dissolved and passing into the culture medium had killed the germs within a definite radius. The only exception was in the case of silver sulphide, which was not surrounded by a free zone as was the case of the others. The width of the free zones accorded with the solubility values of the substances concerned found by other methods. However, the lack of a free zone around the silver sulphide disk is easily comprehended when we learn that one liter of water dissolves only 0.000,000,000,000,000,010.

This extremely valuable experiment throws a definite light on the successful result obtained in infectious diseases by means of colloidal silver and the admirable effects obtained by means of treating wounds with silver foil. It is possible by this means also to make a comparative study as to the germicidal effect of various substances, thus rendering the art of disinfection more definite than it has hitherto been.

Detecting Poisons in Food Substances*

Chemical, Biological and Quantitative Analysis of Foods to Detect Toxic Substances

By Émil Kohn-Abrest, D.Sc.

Director of the Paris Laboratory of Toxicology

IN order to determine the value of any given food material it is necessary to obtain chemical, biological and mathematical information with regard to it. "Alimentary mathematics" has become in fact a distinct branch of mathematical science dealing with such questions as the calorific equivalent and the amount of energy produced or work done by any given dietary ration. Such a determination also involves the obtaining of toxicological information with regard to the substances employed, and it is with the latter department of the science that it is my purpose here to deal.

But first let me inform my readers that there is in France an institution which is unique throughout the entire world—an institution in which all those questions relating to food substances are studied on the most extensive scale. I refer to the *Scientific Society of Alimentary Hygiene and the Rational Alimentation of Man.* This establishment was founded in 1904 and is located not far from the Pantheon at 16 Rue de l'Estrapade.

This society which is under the direction of the most eminently well fitted social and scientific authorities undertakes, among the other tasks which it has set itself, to diffuse among the general public all possible ideas which are of value in domestic economy. Its labors in these directions have been followed and encouraged by the public authorities.

Among those questions which have more particularly occupied the attention of this society since its foundation and which touch on the domain of toxicology from certain points of view, I may mention that of the chemical composition of foods.

Any food substance in order to be normal, *i.e.*, to be habitually suited for ingestion in human organism, should leave within the body nothing which is either injurious or useless; in other words the said food must contain no chemical element other than those comprised in the human body.

The eminent French chemist, M. Gabriel Bertrand, has calculated that a man having a supposed weight for example of 100 kilograms is composed of the following chemical elements:

	Kg.		Kg.
Oxygen	62.810	Sodium	0.260
Carbon	19.370	Potassium	0.220
Hydrogen	9.310	Chlorine	0.180
Nitrogen	5.148	Magnesium	0.040 or 1/2.500
Calcium	1.380	Fluorine	0.007 or 1/16.000
Sulphur	0.640	Iron	0.005 or 1/20.000
Phosphorus	0.630		

It is a simple matter to calculate according to this table the composition of the smallest "gross weights."

Most of the oxygen and hydrogen in the human body are combined to form water; thus in a man weighing 100 kilograms there are 60 kilograms of water consisting of 6.67 H and 53.33 O. Thus if our bodies were desiccated 60 per cent of us would evaporate and there would be left a residue corresponding to that of the mummy of a Pharaoh or to the "living corpse" in Edmond About's famous romance of *The Man with the Broken Ear.*

The rest of the oxygen and hydrogen in the body is combined with nitrogen and carbon to form the so-called organic matter which composes the various tissues of the body. Iron is found in the blood, being the active principle in the haemoglobin of the red corpuscles. Other mineral elements are found in the bones: calcium, phosphorus, phosphoric acid, etc. Phosphorus is also found in the brain in the form of lecithine, while sodium and chlorine are combined to form common salt (chlorine of sodium).

Other elements exist in the body in very small proportions or mere traces, yet these minute quantities are none the less useful to the organism, where they serve as centers of activity for nutrition and other forms of metabolism.

For example, Dr. Gyaya, a Serbian chemist, working in the laboratory of toxicology in Paris, has recently discovered that the amount of zinc found in the human body increases with age, varying between 60 and 350 mg.; there are also present a few centigrams of copper, a few milligrams of silicon, traces of aluminum, and one or two milligrams of iodine and of bromine. . . . Finally, there are one or two millionth parts of lead, a faint trace of manganese and minute amounts of arsenic, not more than one twenty millionth part of the total mass of the human body.

In their natural state farinaceous materials as well as mollusks, fish, and fresh vegetables, contain not merely traces of copper, zinc, and boron, but sometimes quite astonishing percentages of these elements. Oysters, for example, are quite rich in copper and in zinc; in a kilogram of the flesh of green *marennes* there are 138 mg. of copper and 1.157 mg. of zinc. As for boron, the total amount taken in per person per day is no less than 30 mg. in a normal diet, and about the same figures hold true for fluorine. The amount of lead taken into the system daily by means of food is extremely minute, on the contrary, being less than 1/10 of a milligram, while as for "alimentary" arsenic, not more than 1/50 of a milligram is absorbed in the course of 15 years, an amount which is absolutely insignificant with regard to its effect as a poison.

ANTISEPTICS AS ADULTERANTS

In my opinion the use of so-called *antiseptic substances* is the chief cause of the introduction into the human body and excessive accumulation therein of elements which are either quite useless or actually injurious to the organism. . . . It is possible to preserve food materials without the use of chemical substances, by such methods as desiccation, sun-drying, pasteurization, boiling with subsequent exclusion of external germs, etc. All of these processes are purely physical and introduce nothing injurious into the food. With regard to antiseptic substances, however, there are only three means of preserving food by chemicals which are permissible from a hygienic point of view. The best known of these is salting, in which case the food is treated with cooking salt or else preserved in strong brine. Food can also be preserved by saltpeter which imparts to smoked tongues and other meats hues more brilliant than those of nature. Finally, *sulphurous* acid has always been employed for the preservation of wines and other drinks. These are the only antiseptic substances tolerated in France for the conservation of foods, the last mentioned being restricted to beverages alone.

Forbidden to our cuisine are such things as borax, boric acid, the fluorobates, sodium fluoride, salicylic acid, benzoic acid, formol and hydrogen peroxide, to say nothing of other substances which include even a number of very violent poisons! These substances do, indeed, insure the preservation of food products by killing microbes; but while arresting injurious fermentations they also interfere with those desirable ones which are involved in the process of digestion. While antiseptics may possibly be suffered by organisms which are extremely sound and healthy they undoubtedly have an ill effect on the digestive and renal functions of more delicate subjects.

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Finally, our authorities on hygiene also object to the use of antiseptics because they lend themselves so admirably to deceiving the buyer by masking the degree of alteration which perishable foods may have undergone previous to their preservation. It is a regrettable fact that in certain countries the authorities upon hygiene exhibit more tolerance than do those of France. Thus in the United States the use of boric acid and borates is permitted in the packing of meats and egg powders, while sulphurous acid is employed in the preparation of certain dried fruits such as apricots. Australian producers, to mention another instance, are allowed to export borated butters.

Among chemical substances possessed of a powerful antiseptic action, chlorine and its derivatives, together with ozone, form an exception to the rule in one particular instance, *i.e.*, when they are employed not to preserve food but to *sterilize water*.

Water, indeed must be regarded as one of the most important of alimentary substances. The ideal method of sterilizing water is by means of ozone, since this merely introduces the oxygen normally found in properly aerated water. Chlorine is less attractive; however, when such a water supply as that of Paris is concerned it can be sterilized by contact for 30 minutes of one demi-milligram of chlorine with one liter of water.

POISONOUS METAL ALLOYS

Food can readily be made unfit for use by contact with alloys of lead or other poisonous metals. This accounts for the rigid regulations in force with regard to the quality of the tin plate of which cans are made and of the solder employed in sealing them; the tin used in covering the sheet iron must be 97 per cent pure, with not more than 0.5 per cent of lead and 0.01 of arsenic present. Solder used inside the cans must likewise be made of equally pure tin. For outside soldering, however, a solder compound of 2/3 tin and 1/3 lead is permissible. It may happen, however, in case of defective workmanship that a drop of this external solder may penetrate the can and thus expose the consumer to the danger of lead poisoning. Thus we see that the sealing of containers for food is a matter requiring the greatest care. It has been proposed to avoid such accidents by stamping or pressing in the cover or sealing them by means of rubber gaskets, but curiously enough the latter are made of rubber combined with red lead, which is the exceedingly poisonous substance, *lead oxide*.

Lead and its salts when ingested produce in the course of time such serious disorders as "saturnine" colics, paralysis, jaundice, hemorrhages, etc.

But as it happens lead and its salts are very soluble in canned foods—particularly so in sardines packed in oil.

The following table prepared by the late distinguished French chemist, Armand Gauthier, shows the percentages of lead which may be found in canned goods whose containers are defective (the figures given representing milligrams of lead per kilogram of food):

Green peas	2.8	Sardines in oil	45.0
Green beans	2.0	Mackerel in oil	49.0
Salmon	30.0	Tuna fish in oil	30.0
Pate de foie gras	11.8	Lobster	27.0

I may add that while the taking into the system of a few milligrams of lead in a single instance may not be attended with serious results, a long continuation of such a diet inevitably produces a serious or even fatal case of lead poisoning. For this reason when water is taken from lead pipes a considerable quantity of water, at least several liters, should be allowed to flow before any is used. On the same principle the first few drops should be rejected when a siphon of aerated water is opened. It is somewhat reassuring, however, that water from natural springs dissolves lead less than either filtered water, rain water, or distilled water; the solvent action is favored by contact with the air.

Another source of lead poisoning is in the use of utensils containing lead in the preparation of salads since the acetate of lead may be produced by the juice of fruit or even by a marinade of game. Indeed some accidents have occurred through the shot used in killing game coming in contact with such acids as vinegar, etc.

ARSENIC IN FOOD STUFFS

Arsenic is even more dangerous, especially in the form of *arsenious* acid. But arsenic is one of the most frequent impurities in a long list of chemicals. Unfortunately the disturbed conditions which prevail at the present time have made it more difficult than before the war to obtain pure chemicals, but there is a direct relation between the amount of arsenic in certain chemicals and that found in certain foods. In many of the industries concerned in the preparation of food products for the market there is an extensive use of chemicals—e. g., in sugar and glucose refineries, among vintners, and by manufacturers of soups, beef cubes, etc. In the making of glucose, for instance, sulphuric acid is used to change starch into glucose; hydrochloric acid is employed to assist in the solubilization of the active principles of meats from which extracts and broths are to be made; sulphate of lime, or plaster, is sometimes used by vintners and sodium sulphite to make beer "keep," etc., etc.

For these various reasons I have undertaken during recent years, in association with M. Bouligaud, to make a control examination of the purity of chemicals and of traces of arsenic. These researches have proved that arsenic is sometimes present in food products in amounts which must be regarded as alarming when we recall that some forms of this metalloid are fatal to man in doses of only 10 centigrams.

Table I on the next page prepared by Jadin and Astrue shows the amounts of arsenic found normally in plants—amounts vary according to the locality where grown:

As this table shows arsenic is normally *present only in a few thousandths of a milligram per 100 grams* of vegetable substance—a percentage absurdly small with reference to possible toxic effects. Moreover, as shown by Table II, page 327, giving the average amounts of various foods consumed daily in France in 1914, the amount of arsenic ingested in a normal diet is only about 21 thousandths of a milligram per day, or 7.66 mg. per year. The arsenic thus taken into the system is almost entirely eliminated with other waste matter. Yet the vigilance that is required is illustrated by the fact that in 1900 there was an actual epidemic of arsenical poisoning among beer drinkers in Manchester with no less than 4,182 cases, 300 of which were fatal. And these results were due merely to the fact that the brewers had used, for the purpose of fermentation, glucose which had acquired a toxic character from the fact that the sulphuric acid employed in their preparation had contained an undue percentage of arsenical impurities. In this connection it may be remarked that these glucoses are commonly used in the making of pastry and preserves of second grade. Apropos of this it is worth noting that sulphuric acid is itself prepared from iron pyrites (iron sulphide) in which arsenic is the impurity most frequently present.

In beer the traces of arsenic present should not exceed one or two tenths of a milligram per liter—less than the amount permissible in wine (the former being generally consumed in larger amounts).

In our preceding remarks we have dealt with hundredths and even millionths of a milligram—but we have no balance sensitive enough to weigh even the hundredth of a milligram—how then can such slight traces of arsenic be detected in food? The problem is exceedingly delicate, especially since the arsenic is usually so closely combined with the food that it is necessary to destroy the organic material which composes the latter in order to set free the former, while at the same time avoiding the loss of the arsenic through volatilization.

For example if a piece of meat is suspected—100 grams of it

is put through a meat chopper and the pulp is then placed in 35 cc. of a solution which contains about 7 grams of pure crystals of nitrate of magnesia to which there have been added a few pinches of calcined magnesia to prevent acidity, which would favor a loss of the arsenic. The mixture is then heated in an oven to about 250 deg. cent. and then allowed to stand for 3 hours. During this time the mixture is dried and also undergoes torrefaction, so that the organic matter enters into an intimate union with the magnesia forming a sort of spongy amadou or "tinder"; the capsule containing this mixture is then put in a special furnace heated to a dull red glow. Here it is completely calcined in 20 minutes, all of the organic matter being consumed without any loss of the arsenic, the entire amount of the latter having combined with the magnesia to form a compound which is highly resistant to heat—magnesium pyro-arseniate in which the arsenic can readily be detected. A more rapid process of analysis can be employed, provided it is possible to allow for a small loss of the arsenic through volatilization—a loss insignificant where arsenic is present in toxic amounts. In this process the product is diluted in the solution of magnesium nitrate, rapidly evaporated and calcined directly at a higher temperature after the addition of a small amount of nitric acid. By this method the result is obtained in a few minutes.

TABLE I.—ARSENIC IN FOODS

FOOD MATERIAL	ORIGIN	Contents of Arsenic in Thousandths of a Milligram per 100 gr. of the Substance.
CULTIVATED		
1. Mushrooms	Vicinity of Montpellier	6
2. Black truffles	Vaucluse	20
Dry Vegetables		
3. Rice	Japan	7
4. Red haricot beans	Unknown	25
5. White haricot beans	"	10
6. Chick peas	"	9
7. Split peas	"	26
8. Lentils	"	10
Fresh Vegetables		
9. Artichokes	Vicinity of Montpellier	10
10. Salsify	"	7
11. Chicory	"	10
12. Prickly artichoke	"	9
13. Lamb's lettuce (Valerianella olitoria)	"	9
14. Lettuce	"	23
15 Spinach	"	9
16. Pumpkin	"	9
17. White kidney beans	"	20
18. Green peas	"	4
19. Celery	"	20
20. Carrots	"	5
21. Radishes	"	10
22. Water cress	"	12
23. Cauliflower	"	8
24. Wild asparagus (tips)	Calc. Garrigues of Montpellier	10
25. Leeks	Vineyards	3
Dry Fruits (Edible Part)		
26. Walnuts	Lozère	13
27. Hazelnuts	Larzac	11
28. Almonds	Vicinity of Montpellier	25
29. Dates (Var. Déglet and Beida)	Algeria	12
Fresh Fruits (Edible Parts)		
30. Chestnuts	Le Vigan	5
31. Apples (Var. Reinette)	"	5
32. Pears (Var. Royale)	Spain	7
33. Oranges	"	11
34. Mandarins	Blidah	12
35. Pineapples	The Azores	8
36. Bananas	"	6

Our next task is to detect the arsenic contained in the ash. The latter is dissolved in a small amount of water acidulated with sulphuric acid, after which the liquid is introduced drop by drop into the well-known apparatus invented by Marsh, which is merely a hydrogen generator. If the slightest trace of arsenic enters this apparatus the highly toxic gas known as *arsenuretted hydrogen* will be produced; this gas has the odor of garlic and can readily be distinguished from pure hydrogen. The apparatus is provided with a glass tube having a rather small bore and drawn out at one end so as to be very narrow. The hydrogen escaping from the aperture at this end of the tube is lighted, and in case it contains any arsenuretted hydrogen the arsenic will be condensed on the cold wall, forming thereon mirror-like spots. By placing a saucer in front of the flame at regular intervals a number of spots can be obtained, each of which contains 1 or 2 hundredths of a milligram of arsenic. However, it is no longer the custom to form these spots, since this involves a considerable loss of arsenic. *Rings* are produced instead; to do this it is only necessary to apply (through the glass tube) sufficient heat to the gas at the point where it is liberated and to cool the end of the tube. . . . A ring of metallic arsenic will thus be deposited on the cold portion of the tube—the more arsenic the bigger the ring deposited.

TABLE II.—AVERAGE CONSUMPTION OF ARSENIC IN FOODS IN FRANCE

DAILY RATION OF FOOD	Average consumption per Day in Grams	Content of Arsenic in This Quantity in Thousandths of a Milligram	Content of Arsenic in 100 gr. of the Substance in Thousandths of a Milligram
Bread	420	2.9	0.69
Boned meat	180	1.8	1.0
Fish	35	4.3	12.9
Eggs (minus shell)	24	0.05	0.2
Leafy vegetables	250	0.5	0.2
Potato	100	1.12	1.12
Milk	210	0.1	0.4
Wine	518	2.9	0.5
Sea salt	10	2.3	23.0
Drinking water	1,000	5.0	0.5

HYDROCYANIC ACID IN BEANS

Some 15 years ago there was offered on the Bourse a cargo of "Java" beans at just half the price of our good French beans. But having aroused suspicion they were analyzed and found to contain prussic acid! They proved to be the horrible "Java peas," a variety of the *Phaseolus lunatus* which was studied in 1901 by the English scientists, Dunstan and Henry; . . . as its name implies this bean is crescent-shaped in contrast to our own haricot beans which are somewhat ovoid in shape. The Java beans also have a somewhat bitter after taste which is lacking in our beans. For this reason they can be detected by chewing one of them, which is not dangerous. However, they can also be detected by a very simple chemical process devised by Professor Guignard and based upon the property possessed by certain papers impregnated with colored reagents of changing color under the influence of acids.

There are numerous varieties of the *phaseolus lunatus*, found not only in Java but in Madagascar, Reunion, the Cape, etc. While the degree of toxicity varies, they all possess the com-

mon property of yielding prussic acid merely through maceration in cold water. The most poisonous among them are those called Java peas, bitter peas, kratock peas, or Achery peas. In a single lot of these seeds variously shaded and striped, I have found some which yielded as much as 3 gr. of hydrocyanic acid per kilogram of peas, *i.e.*, enough to kill 60 people. Other varieties of the *phaseolus lunatus* yield only from 1 to 3 decigrams per kilogram of hydrocyanic acid; these include especially the red or white haricot beans from Burmah, a variety in which the seeds are, in general, smaller and thicker than Java peas. Finally, a more cultivated variety also exists which yields only a few centigrams of hydrocyanic acid per kilogram; namely, the large white or pink haricot beans from Lima, the Cape, or Madagascar.

The government has formally forbidden the importation of haricot beans of the "Java peas" type and of all flour or other food products made from them. Burmah beans are tolerated on condition that the amount of hydrocyanic acid does not exceed 200 mg. per kilogram of the seeds or materials made from them, but in reality this limit is too high. The ration of beans often amounts to about 100 gr. per day and it would be far from prudent to consume very often such large quantities of a product containing such a percentage of prussic acid, especially when the water in which they have been soaked has not been thrown away. Hygienic authorities, therefore, have advised that the permitted percentage of prussic acid per kilogram should be reduced from 200 mg. to 100 mg. If this were done it would result in the exclusion of Burmah beans as food products. English experiments have shown that the third class of beans imported both from the Cape and from Madagascar, including both white and red, can be used as food without inconvenience. Among other food plants containing prussic acid I may mention the manioc from which tapioca is made. However, most of the maniocs from Brazil or from Reunion yield such small amounts of prussic acid, only a few milligrams per 100 grams, that they are not dangerous.

Hydrocyanic acid does not exist in the *free* state in these exotic beans. It proceeds from the splitting up of those chemical compounds known as glucosides. All of these have the common characteristic of undergoing in the presence of water a special sort of decomposition called *splitting* or *hydrolysis* in the course of which they liberate various substances besides the glucose from which they derive their name. But in order for this hydrolysis to be produced some other special agent must be present, either a mineral acid or a "ferment" called a *diastase*. In the absence of water the glucoside and the diastase will not react upon each other. But as soon as these two substances come in contact through the *soaking* of beans which have been more or less bruised this hydrolysis is effected and the glucoside is then decomposed into glucose, alcohol (or acetone), and *hydrocyanic acid*.

While the diastase does not resist heat the cooking of beans is not enough to destroy their toxicity. In the first place it is difficult entirely to destroy the ferment by boiling, and in the second place the toxic glucoside does resist heat, so that when ingested even without the diastase it is sure to find in the intestines ferments capable of causing its injurious decomposition.

It is by a mechanism of analogous nature that prussic acid is produced in many other vegetable products, such as the leaves and fruit of the cherry laurel and the fruit and kernels of the prune, apricot, cherry, etc., as well as in bitter almonds.

The amount of hydrocyanic acid set free by the action of water upon the kernel of the stones of peaches, plums, etc., is very variable. . . . A case is known in which a small child died from having eaten just 2 kernels of peach-apricots.

When bitter almonds are macerated the amount of hydrocyanic acid set free varies from 1 to 20 per cent; 5 or 6 bitter almonds are enough to cause the death of a child. The percentage is still higher in cherry stone kernels, as much as 3.5 gr. of HCN having been obtained from one kilogram. Thus "kirsch," the excellent brandy obtained by distilling cherries, contains, besides the "quetsch" and the "prunelle," hydrocyanic acid; from 30 to 100 mg. per liter have been found on analysis—this, to be sure, is an inconsiderable amount, but adulterated kirsch and certain artificial kirsches made by macerating the fruit of the cherry laurel in alcohol, etc., may contain much larger amounts of HCN.

THE CONVERSION OF SAWDUST INTO CATTLE FEED

Recent investigations carried out at the Forest Products Laboratory indicate that the sawdust of coniferous woods can be converted into a wholesome cattle feed.

The process for preparing such cattle feed depends upon the conversion of part of the wood into sugar by cooking it for about fifteen minutes with a dilute acid under 120 lb. pressure. In this treatment about 20 per cent of the wood is converted into sugar and the remainder rendered more digestible. The sugars are then extracted from the digested dust with hot water, the acid is removed from the resulting solution by neutralization, and the liquor is evaporated under reduced pressure to a thick syrup. The concentrated sugar solution thus obtained is then mixed with the residue left after cooking and the whole is dried to less than 15 per cent moisture content. The finished material is darker than the original sawdust, is very brittle, and contains a larger proportion of fine dust.

A preliminary feeding trial, using a product prepared in this way from Eastern white pine, was conducted by the Wisconsin College of Agriculture with favorable results. Three cows were fed by the reversal method for three periods of four weeks each. In the first and third periods they were given an excellent ration, consisting of alfalfa hay, corn silage and a concentrate mixture of 55 parts of ground barley, 30 parts of wheat bran and 15 parts of linseed meal. In the second period hydrolized sawdust was substituted for part of the barley, 2 lb. of sawdust being fed in place of each pound of barley, as it was not expected that hydrolized sawdust would have as high a feeding value, pound for pound, as barley. The mixture used during the second period contained about 26 per cent of hydrolized sawdust. At no time was any difficulty experienced in getting the cows to clean up this concentrate mixture. The cows maintained their production of milk in the second period as well as in the first and third and showed an appreciable increase in butter fat production. A decided increase in weight was noted during the period in which they were fed the treated sawdust.

While no definite conclusions can be reached from this brief trial, the results do show that cattle may be fed a limited amount of hydrolized sawdust with beneficial results. It should be pointed out that hydrolized sawdust contains only a negligible amount of protein and that it must necessarily be fed in conjunction with other nitrogen-containing materials. In both rations used in this trial plenty of protein was furnished by the other feeds used.

We wish to emphasize the fact that these experiments are preliminary and that as yet the laboratory is not in position to advise as to the commercial application of the process. Further trials will be carried out to furnish additional data on the feeding value and methods of preparation.—From *Chem. and Met. Eng.*

SUBSTITUTE FOR MILK AND CREAM

A patent has been granted to G. D. Thevenot, U. S. 1359633, Nov. 23), on a liquid food simulating cow milk. It is prepared by cooking soy beans until softened and sterilized and the coloring matter has been removed, separating the free liquor and crushing the solid material to a fine pulp, mixing the latter with sterilized and slightly alkalized H_2O, digesting with proteolytic enzyme in the presence of NaCl, separating the H_2O and the material which it carries in solution and suspension, and adding to it fats, oils and sugar.—*Chemical Abstracts.*

AS A LAST RESORT SHOOTING A LIFE LINE UP TO PEOPLE TRAPPED IN A BURNING BUILDING

OFFICER TALKING TO FIREMAN EQUIPPED WITH A TELEPHONE HELMET

Modern Fire-Fighting Equipment

How Our Firemen Meet the Ever-Growing Problems of Fire Prevention and Control

By Robert G. Skerrett

Photographs Copyright by Keystone View Co., Inc.

FIRE worshippers we are not; and yet how many of us realize the tribute paid yearly in this country to devastating flames?

Each twelvemonth the material and mortal sacrifices due to conflagrations reach staggering totals; and still we deem ourselves quite up to date. According to the latest figures available, fully 15,000 persons are burned to death and 17,000 others are hurt by fire annually. The property losses from the same fundamental cause aggregated in 1919 not less than $325,000,000. In the course of each week substantially 890 dwellings are thus destroyed right along; and the worst of it is, so it is authoritatively stated, 65 per cent of these fires are of trivial and preventable origin.

During the last decade we reared more than $900,000,000 worth of new buildings, but within that span structures representing a loss of a quarter of that sum went up in smoke. Modern conveniences abused have, unfortunately, levied their toll in this way. For example, two years ago, property to the value of well-nigh $15,500,000 owed its destruction primarily to electricity; and the careless handling of the electric iron was responsible for 46 per cent of that damage. The heedless disposition of lighted matches and burning cigars and cigarettes stands out conspicuously in the causal records of a great number of disastrous conflagrations.

These data are given in order that the average citizen may grasp the burden that is now placed upon the fire departments of our communities; and the more populous the city the harder the task confronting the fire fighters. Not only must these men smother the flames with all possible dispatch but it is equally incumbent upon them the while to minimize as far as practicable injury by water. In crowded business and industrial sections one good-sized fire may gravely affect the welfare of hundreds, yes, thousands, of persons and create economic disturbances of a magnitude far beyond that of the immediate property loss involved.

Not so many years ago, fire fighting, even in some of our principal cities, was little better than elemental in the methods and the facilities employed. Apart from the steam-pumping engines and various long-used equipment, success in the struggle rested in the main upon the splendid audacity and courage of the personnel of the fire departments. Dash and daring were the outstanding assets; and often these men paid the supreme price for their thrilling and reckless self-forgetfulness.

Today the trained fire fighter must be no less intrepid than his fellows of the days gone, but he is expected to exercise caution and cunning and to utilize agencies that add immensely to his powers of effective service. In short, fire fighting, like modern warfare, has its recognized strategy and its special weapons, and the work is more than a display of skill—it is proof of applied science and an education about which the average citizen knows but little. Many men and many minds are wrestling ceaselessly with the ever-present problem of fire prevention and fire control; the engineer, the architect, the chemist, the electrician, and the inventor are all contributing to the common cause of security. In order that we may bring to a focus what has been done in this field of protection, let us tell something about the fire-fighting equipment of the nation's foremost city.

Greater New York is probably unparalleled in the task it

presents to a fire department because of its densely populated districts and the prevalence of numerous towering structures. It is equally true that no other municipality the world over involves so tremendous a fire hazard by reason of concentrated wealth and its extremely diversified business and industrial undertakings. The advent of the skyscraper, the wide adoption of steel-framed buildings, and the presence of thousands of people in a single office edifice—not to mention relatively narrow streets—all combine to place obstacles in the paths of the fire fighters. Within its gates, the city of Greater New York has more than 5,600,000 residents, and a daily transient population somewhere in the neighborhood of half a million persons. Further, the assessed property valuations aggregate substantially $9,000,000,000.

USING A CUTTING TORCH TO FREE A MAN CAUGHT UNDER AN ELEVATOR

In these circumstances, it is essential that the fire-fighting instrumentalities should be brought into play when needed with the least delay, and from the very nature of things this would not be feasible but for the development of truly up-to-date apparatus of divers sorts. Time and again conflagrations have broken out within the limits of the Greater City which have necessitated the concentration of the major part of the fire-fighting force upon a restricted area, and the men and apparatus have been drawn from districts five, ten, and more miles away. Remembering that weather conditions may seriously hamper street travel, much has depended upon bringing up reinforcements with celerity. As has been said by one eminent fire chief, "The most dangerous time at all fires seems to be the first thirty minutes."

In order to deal with this critical period, steps were taken only a few years back to motorize the fire apparatus, and today well-nigh 66 per cent of the equipment is self propelled. This includes engines, hose wagons, hook-and-ladder trucks, water-towers, rescue wagons, fuel wagons, and cars for the fire chief. At the start, the steam engines were motorized by substituting gasoline tractors for the horses and the front wheels, which made it practicable to increase enormously the mobility of the existing engines. Latterly, however, there have been introduced gasoline propelled and pumping engines, which rely entirely upon internal combustion motors. These machines can each of them deliver 1,000 gallons of water a minute; and their operative economy is several hundred dollars lower per year than the erstwhile horse-drawn "steamers."

The automotive equipment can cover long distances at speeds ranging from 20 to nearly 40 miles an hour, and can negotiate grades at full tilt which would slow up to a walk the pace of the sturdiest of draft animals. For a straight-away run, horses reach their limit in about five miles, and from there on they become exhausted quickly even when street conditions are favorable. In an expansive city, when a raging fire calls for the assembling of many companies, every minute saved in getting to the point of attack is of vital concern. As a means for dealing with the fire needs of less thickly settled sections, the city has at its command what are known as combination hose wagons and chemical engines, and these "scouts" can tear along at a speed of fully 40 miles an hour.

These typically up-to-date agencies are provided with high-power gasoline engines, and carry two 35-gallon metal tanks charged with a chemical fire-smothering mixture. Within their operative zones, they are commonly the first to show up at a blaze; and in hundreds of instances they have been able to put the fire out before the heavier engines arrived. By their quickness of action they have succeeded in nipping conflagrations in the bud—thus preventing damage that might otherwise have totaled very large sums.

The effectiveness of the big gasoline propelled and pumping fire engine has been demonstrated in a spectacular fashion. Awhile ago one of these machines was connected by hose with the standpipe of the towering Woolworth Building and forced a stream of water to the fifty-eighth floor, 730 feet above the street, at which point it was discharged at a pressure of 67 pounds. The pressure at the engine was 450 pounds; and the fire chief declared that the powerful apparatus would have been able to drive the water to a height of 1,000 feet had piping of suitable size and length existed for that purpose. In passing, let it be said, that every tall building in Greater New York is provided with a standpipe system, with hose and hose connections on every floor—water being supplied by suitable pumps in the basement which charge tanks placed high aloft having storage capacities for thousands of gallons of water. The administrative personnel of these structures constitute an auxiliary fighting force, and their function is to bring into play immediately the facilities at hand and to battle with the blaze until the men of the city fire department come to take over the work.

The pumps of a skyscraper and the tanks feeding the standpipe and its branches can be readily reinforced by a very important link in the fire-fighting installation of the metropolis. At the outside of each of these structures there is what is termed a Siamese-twin coupling, which makes it possible to join by hose the standpipe equipment with the high-pressure main running beneath the street. This main is part of a great circulatory system that has its impulse centers at strategically placed stations which draw salt water from the neighboring rivers. The high-pressure conduits cover the more densely occupied business districts of New York; and a veritable network of water mains traverses these areas, with hydrants rising from the pavement at frequent intervals.

FIREMAN WITH SMOKE HELMET BRINGING OUT A COMRADE NOT THUS EQUIPPED FROM A GAS-FILLED SUBCELLAR

When a fire alarm is sent in within these areas, the high-

CUTTING AWAY THE IRON BARS WITH A BLAUGAS TORCH TO FREE A MAN WHO HAS BEEN TRAPPED IN A BURNING BUILDING

USING A PULMOTOR TO RESTORE A FIREMAN WHO HAS BEEN OVERCOME BY SMOKE. HE WILL SOON BE READY TO RESUME HIS DANGEROUS WORK

pressure hose wagons and the water-towers are the first to respond. The hose lengths are coupled to the high-pressure hydrants, and the water is furnished in streams at a pressure considerably greater than that generated by the regular fire engines. The water-towers rise many feet above the street level and make it practicable to throw their battering, quenching floods much higher or to direct them far into the depths of a burning building without the aid of ladders.

At each high-pressure station there are installed five electrically-driven centrifugal pumps, each capable of discharging 3,000 gallons of water a minute at a pressure of 300 pounds or 5,000 gallons a minute at a pressure of 150 pounds to the square inch. The entire equipment at the separate stations is controlled from a switchboard, and a single engineer has the whole plant at his command. Recording charts show him what is the drain upon the apparatus, and in this way he brings his pumps successively into action to meet the requirements of the firemen battling with the more or less distant blaze. At eight o'clock in the morning and at five o'clock in the afternoon, every day, even if there is no fire, the pumps are set in motion and run until the pressure is built up to 200 pounds. It is so maintained for thirty minutes for the purpose of testing the mains. Thus twice every twenty-four hours the engineers make certain that all is well with the distributing system.

Five years back the Fire Department of New York City made an important change when it secured three 1,000,000 candle power searchlights for use at night. Up to that time, the searchlights were installed upon the driver's seat and were energized by the steam engine upon which they were mounted. The cost of operation was not only very high but the light was unsatisfactory. In fact, the engines were hampered in their other service because of their searchlight outfit. The new searchlights are attached to water-towers; can be elevated where they will command a wide field; and besides giving much better illumination each of them actually nets a saving annually of $12,000. They are able to send their penetrating beams into a dark building or through a smoky atmosphere that would prove a veritable blanket to the rays of the lamps previously provided.

Not so long ago the firemen had nothing to guide them in groping about in an inky cellar or the darkened passages of a structure except an oil lantern. But now, thanks to the inventive genius of Thomas A. Edison, the men detailed for work of this sort carry portable searchlights energized by storage batteries. These lamps are of 1,000 candlepower, and are arranged to be attached to the front of the helmet or in any other position that is desirable. The firemen thus have both hands free and yet can count on the aid of far greater illumination than that of the less efficient and frequently hampering lantern.

Probably no section of the fire-fighting organization is more interesting than the Rescue Squad or "smoke eaters," as they are generally known to their associates. It was first called into being in 1915 for the purpose of meeting peculiar conditions at fires; and in a short while it demonstrated its value for such work as shutting off ammonia supplies when pipes burst in cold-storage plants; for entering and ventilating drug and chemical establishments during the progress of a blaze; for reaching the seat of a fire in smoky cellars and subcellars; for rescuing persons overcome by ammonia fumes or other gases; and for fighting fires where particularly pungent smoke prevails which renders the ordinary means at hand impotent. The adoption of the smoke helmets, with which the squad is supplied, was inspired by the activities of the U. S. Bureau of Mines in its life-saving efforts.

The rescue company is moved to the point of service by a specially designed motor car, and its equipment includes a Blaugas torch apparatus, two pulmotors, stretchers, a number of smoke helmets, extra cylinders of oxygen for the pulmotors and helmets, fire extinguishers, a life-line gun, axes, etc. The object of the Blaugas torch is to enable firemen to cut through steel rods or other metallic barriers in order to rescue persons trapped behind them or to get into places so as to fight the fire from a more advantageous position. In one test the Blaugas torch cut through a bar of steel 4 inches square in 63 seconds. Hack saws and files had taken more than an hour previously, to sever the iron window rods of a burning building. Similarly, the intense heat of the torch has been used effectively in clearing away the grill work and metal flooring of elevators to release persons held within or caught beneath the cars. Indeed, the mere summary of a year's activities of a rescue squad is interesting because of the diversified performances. For example, in one twelvemonth, the men donned their smoke helmets in 21 instances; employed the cutting torch on 7 occasions; brought the pulmotor into play 6 times; achieved rescues at 4 fires; removed bodies at 3 blazes; extricated people from elevators, etc., on 11 different dates; they raised the ladders at 3 conflagrations; forced doors at 21 fires; opened iron shutters at 8 calls; ventilated buildings by raising windows at 67 fires; ventilated structures through the roof at 34 fires; cut the roofs open at

8 fires; cut up floors at 3 fires; operated the lines at 12 fires; and did many helpful acts when scores of additional emergencies arose.

Time and time again the "smoke eaters" have carried hose into burning houses that could not be penetrated by the rest of the force. It is their practice to work in pairs so that they can assist and mutually protect each other. In particularly dangerous positions, one man goes ahead of his fellow to whom he is linked by a life line, and when this advance "smoke eater" fails to respond to the signal jerks, then his companion knows that he is in trouble and overhauls the rope until he is up to his stricken comrade to lend aid, which usually means dragging him out to the open air.

The speaking trumpet no longer suffices to spread orders and to facilitate communication amid the din and confusion of a conflagration—a much more dependable agency is available. The men of a rescue company are provided with portable telephone sets, and workers out of sight of one another can thus keep in touch vocally and report conditions for the better guidance of the other members of the fire-fighting organization. The public may not realize it, but there are times when the presence of certain chemcials makes it exceedingly hazardous to turn water loose upon them. A blaze might thus be transformed into a tremendous explosion. Therefore, the portable telephone enables the scouting "smoke eater" to reconnoitre and to send back word in time to avoid a possible catastrophe.

There are occasions, when a blaze in intervening floors, renders it impossible to reach by direct means people trapped in the higher stories of a burning building. Their only salvation lies in getting a line to them that will permit their escape beyond the flaming zone. This is now effected by the life-line gun which looks not unlike a magnified pistol. A rod-like projectile is placed in the muzzle of the weapon, and to this is secured a light cord coiled in a canister. When the gun is fired the cord can be shot way aloft. In the hands of a qualified marksman it is entirely practicable to reach in this way the upper floors of a fairly tall structure, wherever people may be in peril. It is only necessary for some of them to haul in the cord and raise the while the life line which has been secured to it. The firemen, by practice, become decidedly expert in shooting the little rocket or rod to the chosen objective—be it a window, a balcony, or a roof.

It is not permissible in a mere sketch of present-day fire fighting to go into detail; but it is probably not an exaggeration to say that one of the prime features of any protective installation is the system of sending in fire alarms. New York City, after many bitter experiences, has wisely placed its signaling wires under ground, and has evolved facilities that supplement one another so that it is well-nigh impossible to prevent rapid communication and the dissemination of calls essential to dispatching successively needful reinforcements to battle with a blaze. According to the district and the nature of the fire hazard it presents, a single alarm summons fire-fighting forces of varying strength. Each alarm turned in goes to the "nerve center" of the fire-alrm system of the borough primarily concerned, and the telegraph dispatchers at headquarters send the alarm to the fire companies over two different wires. First the alarm rings on a small bell in the fire house and then, by means of the second circuit, on a gong in the station. The lesser bell gives the number of the station twice and strikes on every floor in the fire house. The big gong sounds the alarm once, beginning immediately after the signal has been completed on the small bell. The apparatus is generally dashing up or down the street before the large gong has finished its message. Therefore, the repetition of the alarm is virtually a precautionary measure to guard against any wire trouble on the first circuit. As soon as the alarm is sent out, one of the attendants at headquarters ascertains from a box of assignment cards the companies that are at the fire and registers them. These cards enable the operators to know the whereabouts of all of the companies at any moment.

When a box is pulled within a thousand feet of the river front two fire-boats respond in the borough affected and augment the land equipment. New York City's waterfront is about 577 miles in length, and 103 miles are developed and require fire protection. The dock property alone of the municipality represents approximately $180,000,000; and fully two-thirds in value of all of the imports of this country enter through the Port of New York. Therefore, the fire-boats constitute a prime part of the security organization. The fleet is now composed of nine vessels armed with pumps giving each of them a minute capacity varying from 6,000 to 12,000 gallons; and the flotilla's united output totals 70,000 gallons a minute, which is about equal to that of 100 second-class engines. The larger boats are able to drive water inland through lines of hose 3,000 feet in length, and therefore are available for battling with flames fairly remote from the water front. In 1919, the entire fire department used in extinguishing blazes 142,033,503 gallons of fresh water and 84,770,217 gallons of salt water. In that year, despite all that was done, the

FIREMAN FITTED WITH OXYGEN HELMET AND HEAD TELEPHONE REPORTING CONDITIONS IN A GAS-FILLED CELLAR

aggregate fire losses totaled $12,488,258—a per capita loss of $2.08. This was the record notwithstanding that 90 per cent of the fires were confined to the point of origin.

With the present-day facilities at their disposal, and the decidedly complex problems confronting them in many directions, the firemen of a modern city would be quite unequal to their tasks if they were expected to qualify only by casual association. Recognizing this the City of New York has instituted a fire college course, and there the men are instructed in every branch of their work. They are taught, besides, how to avoid and where to expect that dreaded phenomenon, the back draft; they are tutored in the chemistry of fire; and they are shown how to contend with blazing oil and other combustibles which may be rendered doubly devastating if water is turned loose upon them.

Finally, the enlightenment of the public goes on continuously, for the people at large, by reason of carelessness, are directly accountable for the vast majority of our destructive fires.

Blasting with Liquid Oxygen

An Explosive Developed by the Germans to Meet the Exigencies of the War

By S. P. Cortland

Photos by courtesy U. S. Bureau of Mines

MINING by means of liquid oxygen as an explosive has obtained a foothold in the United States, and two important operators in this field of industry are using the novel blasting medium in certain non-gaseous coal mines and in sections where copper ore is dug out by the open-cut method. Such is one of the potentially helpful reflexes of the World War.

The Central Powers had not been long in conflict with the Entente Nations before they realized that they would have to husband every pound of the materials essential to the making of military explosives. Nitrates and glycerin were at a premium; and the Teuton cause was doomed to a sudden collapse unless other shattering mediums could be evolved for indispensable mining and for the execution of undertakings of an engineering and kindred character. Such was the situation, but the pressing question was, What could be counted upon as an efficient substitute? After a little pondering the technicists answered, liquid air.

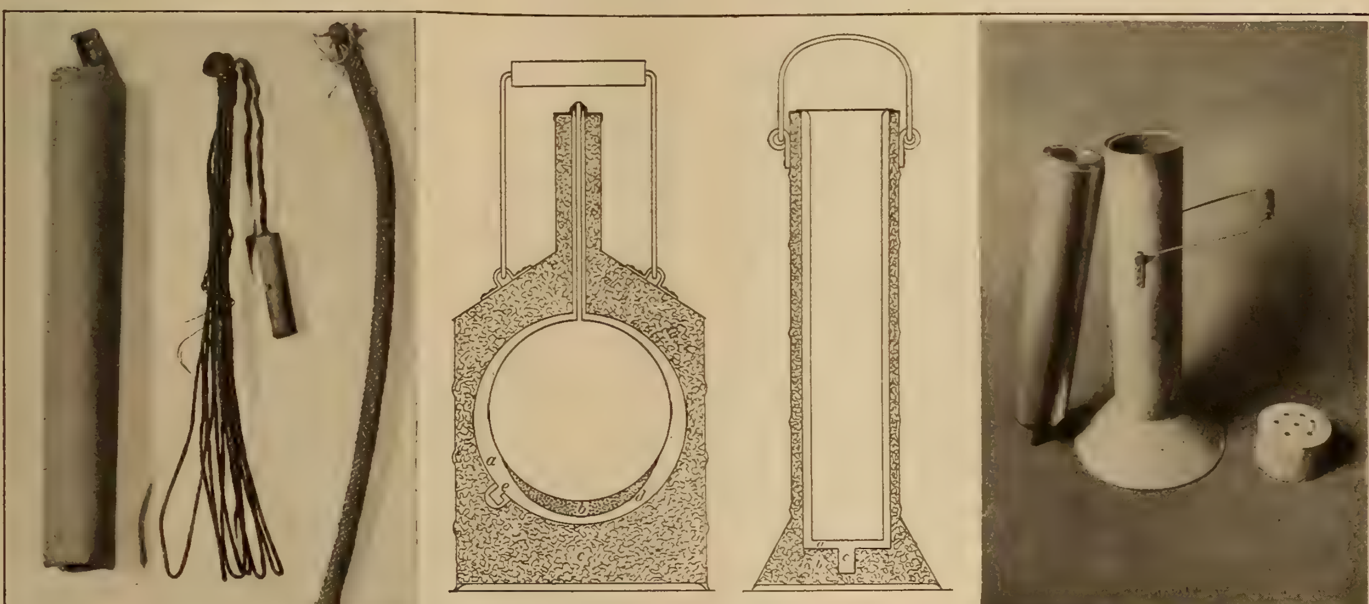
The proposal was not revolutionary, for it entailed nothing more radical than the resumption of developmental work that had been dropped about fifteen years previously. In 1899 liquid air as an explosive then known as "oxyliquit," was tried out during the driving of the famous Simplon Tunnel. Although the demonstrations were declared to be convincing and the results substantially equal to those obtained with like quantities of blasting gelatin, still the use of the patented compound ceased after the death of the engineer who was in charge of the experimental applications.

True, in a desultory way, steps were taken by those commercially interested to perfect the explosive, but the mining fraternity was not responsive, and oxyliquit was looked upon more as a laboratory achievement than as an explosive that could be adopted in every-day practice. When tested during the excavation of the Simplon Tunnel, oxyliquit was a mixture of crude petroleum, soot, and kieselguhr duly saturated with liquid oxygen containing a considerable percentage of nitrogen.

It was the nitrogen factor that did much to impair the reliability of the compound by inducing a lack of uniformity in the explosive action. This is not hard to understand, for the inert character of nitrogen would be apt to slow up ignition and to repress complete and speedy combustion. Twenty-odd years ago, the manufacture of pure liquid oxygen was fraught with many difficulties, and such being then the state of the art there was warrant for skepticism that oxyliquit or any other explosive of that class could ever be expected to compete with dynamite, black blasting powder, etc.

But in 1900 Georges Claude of France brought out an air liquefying apparatus of a markedly superior type; and two years later, Karl von Linde, in Germany, evolved his rectification equipment. From then on the low-temperature fractional distillation of highly-compressed gases moved forward rapidly. Liquid oxygen, liquid hydrogen, and liquid carbonic gases became commercial commonplaces. About 1904 Sir James Dewar invented a way to obtain a high vacuum in a double-walled vessel; and the Dewar flask thus offered a container that could be relied upon to decrease greatly the rate of evaporation of liquefied gases held within it. Despite these various improvements in the art, little attention was devoted to the further practical application of liquid-oxygen explosives until after the fateful 1st of August, 1914.

Soon after the Central Powers laid down their arms in November of 1918, Mr. George S. Rice, of the U. S. Bureau of Mines, went to Europe and made an investigation of the use of liquid oxygen for explosive purposes in Germany, and



CARTRIDGE WITH CARBONACEOUS FILLING AND VESSELS USED FOR SOAKING IT IN LIQUID OXYGEN

The photograph on the left shows the cartridge (9½ inches long), the electric detonator and a piece of the black powder fuse employed by the Germans. The drawing on the left is a sectional view of a liquid air container used by Germans during the war; *a* evacuated space, *b* charcoal, *c* insulating material, *d* screen for holding charcoal in place, *e* attachment for exhausting air. The next drawing shows a vessel for soaking cartridges in liquid oxygen; *a* evacuated space, *b* insulating material, *c* connection for air pump. The photograph on the right shows at the left, a double-walled liquid-oxygen flask; in the center, the carrier lined with felt or other insulating material, while at the right is the perforated cap or cover from which the cartridges can be suspended during soaking.

many of the facts herein related have been furnished by that expert. Further, from other sources, data have become available revealing the extent to which the Germans have adopted the new explosive in various fields of mining since the close of the conflict. All of this information tends to show that liquid oxygen as a blasting or shattering medium has come to stay.

Liquid oxygen alone is not strictly speaking an explosive, but its boiling point is about 298 degrees Fahrenheit below zero. At any temperature from that upward it vaporizes rapidly. If the container be sealed, and the expanding gas be offered no easy channel of escape, the pent-up pressure may become sufficiently great to burst the vessel holding liquid oxygen—the ultimate violence depending upon the external temperature and the strength of the imprisoning walls. But if the flask have a suitable vent, then the frigid fluid is fairly harmless. It is only when the liquid oxygen is combined, through saturation, with a suitable carbonaceous material that it becomes a powerful explosive, and can then be fired either by a fuse or an electric spark. Until the liquid oxygen and the carbon are thus brought together, the ingredients are innocuous. In this respect liquid-oxygen explosives differ fundamentally from dynamite, blasting gelatin, etc., and can be handled with a great deal of freedom in the meantime.

As might be expected, a special technique had to be evolved to deal effectively with an explosive that basally was so unlike the ordinary shattering agencies. At the start there was

LIQUID OXYGEN HANDLING EQUIPMENT USED BY THE GERMANS FOR THE DESTRUCTION OF THE LONGWY STEEL WORKS

some difficulty experienced in manufacturing a satisfactory cartridge, and with this overcome it required some time to learn how to manipulate the charge. Similarly, various carbonaceous substances were tested before the right ones were discovered. Powdered cork, sawdust, soot, ground straw, etc., have been utilized; and during investigations carried out here by the U. S. Bureau of Mines, at the Pittsburgh Experiment Station, carbon in the form of crude oil, lamp black, and wood pulp has been employed. Surely, a rather wide range of choice.

The Bureau of Mines began its researches in March of 1917, and, with the data then available, our technicists sought to find the best way to use the explosive and how to produce it of a strength equal to that of standard dynamite. Different carbonaceous ingredients were mixed with liquid oxygen of varying degrees of purity, and a cartridge of a special pattern was designed. The envelope for the carbon was a small cheesecloth sack averaging an inch in diameter, and was arranged to carry an electric detonator. The cartridge shell was composed of two cylinders of pasteboard—each having one end closed—the smaller sliding inside the larger tube. The investigational work is still under way.

To charge the cartridge, so to speak, the bag, with its carbonaceous filling, is dipped in liquid oxygen for ten or fifteen minutes, and is then withdrawn and placed within the telescoping cylinders. During the soaking period these pasteboard shells are chilled by exposure to the frigid vapor escaping from the liquid-oxygen flask. This vessel, patterned in principle upon the Dewar flask, is a triple-walled affair of metal—the innermost receptacle being successively enveloped by an evacuated space and then by a mass of insulating material. Right beneath the liquid-oxygen container is attached a mass of granular charcoal which is held in place by a perforated metal screen. When this charcoal is chilled by the neighboring liquid oxygen, the refrigeration serves to increase immensely its gas-absorptive capacity; and by reason of this phenomenon the exhaustion of the so-called vacuum chamber is made more nearly complete. In this way the vacuum, primarily induced by pump, is automatically corrected from time to time to take care of impairment. The container is used to transport the liquid oxygen from the point of preparation to the scene of operations, and is provided with a stopper with a small vent through which the "steam," that is continually given off, can reach the atmosphere.

The soaking receptacle, also doubly insulated, is a wide-mouthed contrivance to facilitate the dipping of the cartridges. The liquid oxygen is not poured into it until it is time to get ready for blasting. Inasmuch as the object is to effect the complete combustion of all of the carbonaceous material so that the resultant fumes will be CO_2 rather than poisonous carbon monoxide, it is essential that enough liquid oxygen shall be absorbed by the cartridge to bring this about. Accordingly, in determining the amount of liquid oxygen for this purpose it is essential that the weight of the pasteboard tubes as well as the cheesecloth shall be added to that of the carbon in the bag.

The procedure adopted in loading a hole for blasting by our experts is substantially as follows: When the assembled cartridge, carrying a detonator with the electric circuit projecting, has been duly saturated with liquid oxygen and is frozen stiff, it is shoved into the drill hole and followed by a wad of cotton. Next, a small brass tube is slid into the hole and the rest of the cavity tamped with moist clay. On the withdrawal of the tube a passage is left for the emission of vaporizing oxygen prior to the detonation of the explosive. It is said that this escaping oxygen, if open lights are used, presents practically the only cause likely to lead to premature firing. However, if there is neither coal dust nor fire damp present, this risk is really no greater than when any other high explosive is employed, and the menace is less than when black blasting powder is charged into a drill hole with bare flames near by.

As the reader has probably grasped, liquid-oxygen explosive dissipates its potential violence through evaporation if not detonated within a short time—in practice ten or fifteen minutes after removal from the soaking bath. While this has its drawbacks, and limits the number of holes that can be charged and then fired simultaneously, still there are consequent advantages. Unexploded cartridges of dynamite or black blasting powder are hazardous things to dig out after misfires, and more than once have occasioned unexpected catastrophes when hidden away in the coal or ore coming from a mine. Half an hour after a liquid-oxygen cartridge has failed to detonate it becomes impotent through evaporation.

During a series of comparative tests by the Bureau of Mines with its ballistic pendulum, used for measuring the force of explosions, it was found that the unit strength of the liquid-oxygen explosive prepared by the Government technicists was 4 to 12 per cent greater than that of 40 per cent nitroglycerine; and when tried in a practical way at a stone quarry near Pittsburgh the shattering work done was at least equivalent to that of 40 per cent dynamite. It was also proved that in an atmosphere containing 4 per cent of methane and with coal dust present, both the dust and the gas were ignited. Therefore, the new explosive cannot be used in gaseous coal mines. The firing of the gas and the dust were due to the increased duration of the flame of the liquid-oxygen blasting material; and, furthermore, the actual length of the flame was 2½ times longer than that of the average permissible explosive.

With a comprehension of the limitations peculiar to liquid oxygen in this new field, let us see what Mr. Rice and others, acting for the U. S. Bureau of Mines, learned while abroad. As may be recalled, the Germans systematically destroyed the steel plants at Longwy before retreating, and as a preliminary to this wrecking they installed a Linds liquefying equipment. The cartridges used were of strong paper and were made by wrapping it three times around a split, wedge-shaped wooden former, circular in cross section. The taper being designed to facilitate taking off the finished cartridge shell. The outer edge of the paper and the bottom of the container were glued together; and after loading with soot or other carbonaceous material, the surplus paper at the top was merely crushed in or folded down and over. These cartridge cases were 12 inches long and 1.2 inches in diameter. Fuses were provided with detonators having pointed ends; and the carbonaceous material with which they were charged was cork charcoal. The detonators were made ready for service by soaking in liquid oxygen.

THE CARTRIDGE, THE TELESCOPING PASTEBOARD SHELLS AND THE ELECTRIC DETONATOR WIRES

At the Aboué iron mine, in the Briey district, the Germans set up apparatus for the manufacture of liquid-oxygen explosives when they took possession of French Lorraine, and as long as they held the territory they employed the new explosive in their mining operations. Again, at the Moyeuvre iron mine, in what was formerly German Lorraine, the Teutons assembled a liquid-oxygen plant, and the French, when they recovered the area, promptly familiarized themselves with the facilities and continued to make successful use of the explosive.

The machinery was started in 1916; was driven by a 300-horsepower motor; and was capable of turning out 75 liters of liquid oxygen hourly. The cartridges adopted for service at that mine were 9 inches long and about 1½ inches in external diameter. They were filled with abraded wood somewhat coarser than ordinary sawdust. The practice was to soak the cartridge for 15 minutes, and the explosive was effective for a quarter of an hour after removal from the dipping vessel. The latter was large enough to hold four cartridges at a time—each of which weighed 100 grams before saturation and 300 grams thereafter. A 5-liter carrying can was the vehicle for transporting the liquid oxygen to the mine, and one of these was sent to each chamber in which worked two miners and one or two loaders. Five liters of liquid oxygen sufficed for making up from 12 to 13 cartridges, and was ample for an 8-hour shift. Indeed, there often remained in the can one or two liters of the liquid oxygen when that vessel was returned to the station for refilling. The rate of evaporation was only 50 grams per hour. Soot was tried as a carbonaceous filling, but it yielded more poisonous gas than the ground wood.

In the Moyeuvre iron mine the ore is dense and strong but shoots easily. Before liquid-oxygen explosive was adopted blasting powder was used. When visited by our representatives, the custom with the French miners was to drill one or two holes, which they then charged and fired. The liquid-oxygen explosive produced such inappreciable amounts of carbon monoxide that the men were able to return immediately to the face after the shot had been fired. The smoke was light and caused no discomfort. At each shot two tons of ore were thrown down. It seems that the new explosive can be made more shattering, like dynamite, by employing finer carbonaceous material. A liter of liquid oxygen cost 1 franc 23 centimes, and with cartridge material and fuse added, the outlay was 1 franc 45 centimes—29 cents pre-war value.

In 1915, according to a German authority, experience disclosed that one kilogram of dynamite would produce 10 metric tons of coal, while a kilogram of liquid-oxygen explosive would bring down 15 tons of coal. That is to say, the dynamite per ton of coal cost 14 pfennig (3½ cents) and the liquid-oxygen explosive for the same service entailed an outlay of 8.3 pfennig (2.1 cents). The same student of the subject has estimated that, even when making liberal allowances for evaporation losses, liquid-oxygen explosives will be less expensive throughout a working year of 300 days than dynamite, which does not dissipate itself or lose its strength in storage.

At Moyeuvre the liquid oxygen was kept in a big reservoir in the liquefying station, and the officials there declared that the stuff would stand with practically no loss of moment during a period of 24 hours. That apparatus represented an expenditure of 30,000 marks which, at the pre-war value, meant an outlay of $7,500. All of the liquefying apparatus in use by the Germans were not of a stationary type. One of the most interesting developments by them has been the construction of small portable outfits having a capacity of from 3 to 5 liters of liquid oxygen per hour. These machines can be moved about on motor trucks, and the engines of the vehicles are readily coupled up with the liquefying installation. This puts liquid-oxygen explosives within convenient reach of various sorts of engineering undertakings. Liquid oxygen was thus employed during the excavating of subways in Berlin; and there is ample warrant for the assumption that mobile liquefying plants played their part in the fields of military operations.

A secret staff document, captured by the British in 1918, contained minute instructions for the Royal Prussian Pioneers covering various applications of liquid-oxygen explosives in the theater of war; and it was specified that the blasting material was admirably suited for the work of cutting communication tunnels and dugouts, for the driving of mine galleries, and for the rapid construction of shelter and other trenches. Indeed, it was officially declared that it was well adapted to the destruction of all classes of obstacles.

Manifestly, if American manufacturers can turn out equally satisfactory portable liquid-oxygen apparatus their employment will be advantageous and do away with the transportation and storage of the dangerous explosives now commonly used. It is said that liquid oxygen, when spilled upon the bare skin, will not produce a burn if shaken off promptly. However, the German military authorities caution against wearing gloves when handling liquid oxygen, lest the latter be

WITHDRAWING THE CARTRIDGE FROM THE DIPPING VESSEL

absorbed by the gloves and thus held in contact with the skin long enough to occasion injury.

The U. S. Bureau of Mines has recently stated that the Teutons have greatly amplified the service of liquid-oxygen explosives; and, according to statistics issued since the armistice, the Germans have available a total of 136 liquefying plants with a gross capacity of 3,797 liters of liquid oxygen per hour. This possible output no doubt is designed to take care of stand-by and other losses, and probably covers a capacity in excess of actual needs. Even so, assuming that but one-fourth of the potential yield of liquid oxygen is utilized regularly for nine hours daily and three hundred days in a year, this would be equivalent, in the course of a twelvemonth, to quite 5,346,000 pounds of the fluid. Such a quantity of liquid oxygen would produce explosives corresponding in effect to about 8,000,000 pounds of dynamite. At this rate, the substitution of the liquid-oxygen explosive would effect an annual saving of substantially $532,000. The Germans are blasting with the novel material in coal mines, iron mines, and in the mining of salt and potash.

As must be evident, liquid oxygen is the chief cost factor in the preparation of the new explosive—the other ingredients being readily obtainable at very low prices. Therefore, the extensive adoption of liquid oxygen in the field of blasting will depend upon the availability of improved liquefying machines. Work done both in Germany and in France latterly give great promise of the realization of this desideratum, and we can no doubt count confidently upon our engineering concerns profiting by European developments and their own experience in manufacturing compressors, etc.

Despite their advantages, liquid-oxygen explosives have their limitations, but these drawbacks do not overshadow the superiority of the novel explosive in those departments of mining already specified. The lower cost per unit of material blasted is in favor of the liquid-oxygen compound, especially in view of the steadily rising cost of the ordinary standard explosives. And then there is that outstanding virtue of greatly augmented safety—something that is of prime importance.

WHENCE COMES PETROLEUM?

Now that the world actually faces in a not too distant future, the serious diminution, if not the entire disappearance of those vast subterranean lakes of crude oil, the exploitation of which has so marvelously advanced man's comfort in a myriad of ways, the still unsettled question of its origin is more than ever of import to the general public as well as to men of science. There are two leading theories with regard to the formation of petroleum, one of which regards it as of volcanic origin, while the other ascribes it to a resolution of the débris of animals. The question is discussed at some length by M. L. Gentil in *Chimie et Industrie* (Paris) for December, 1920, but we shall here confine ourselves to a brief abstract of the argument for which we are indebted to *Le Génie Civil* (Paris) for February 5, 1921.

The organic hypothesis has been chiefly formulated and supported by certain Roumanian geologists, particularly Professor Mrazec. The hydrocarbons found in nature have two distinct sources: an internal origin, in which case they are found in metallic veins in rock, and an external origin, in which case they are of organic provenience and are found scattered through the strata of the sedimentary rocks. Professor Mrazec terms those strata in which the remains of plankton are found "mother rock" and considers that the hydrocarbons present in these layers are produced by the decomposition of the plankton.

In Roumania, these mother rocks are Tertiary: the most ancient of them which are very rich in foraminifera with some traces of fishes are Paleogenic; the more recent ones form a part of the "Saliferous" strata belonging to the first half of neogenic formations.

The latter strata include the richest mother rocks found in Roumania, but curiously enough, petroleum is not found in these but in the more recent strata of the upper neogenic deposits. This indicates a movement of liquid hydrocarbons through which they have impregnated very permeable territory where strata of sand predominate. This so-called migration of petroleum is oftener upward than downward.

It is only when the sand is super-saturated that the oil can be obtained by driving wells. The roof over beds of petroleum always consists of a rock which is impermeable enough to stop the upward migration of the liquid. In Roumania the best roof is the Pontian, and this explains why most of the exploitable petroleum is found at the Meotian level.

There are various reasons for the migration of the oil, some of which depend upon its composition, as when the gaseous elements contained exert an upward pressure. In other cases the migration is due to various outside causes such as an increase in the expansive force of the gases caused by the temperature of the earth, by the infiltration of water causing the lighter oil to move to its surface, and finally, by orogenic (or mountain-rearing) forces capable of exerting an action from a considerable depth.

An examination of deposits of petroleum yields arguments both favorable and unfavorable to the theory of organic origin. Among the favorable arguments we may mention: the similarity of petroleums to other mineral fuels, the fact that such deposits are generally found not far from gypso-saline strata, their connection with certain tectonic zones exhibiting no eruptive character, etc. Among unfavorable arguments is the fact that increasingly deep borings have succeeded in finding petroleum above strata which had been supposed to belong to the mother rock.

According to M. Launay, the mineral hypothesis is still more untenable. However, it is favored by the ordinary and abundant presence of hydrocarbons in the gaseous discharges from volcanoes, by the existence of carburetted substances in numerous metal-bearing veins and by the mobility and thread-like arrangement which gives layers of petroleum much the aspect of internal mineral veins. The Bucharest authority, Professor Murgoci, believes that Roumanian petroleum must have resulted from the condensation of hydrocarbons which emanated originally from deep lying basic magmas, through fissures, faults, and surfaces of landslides occurring during the formation of the Carpathian Mountain chain. M. Gentil inclines toward the volcanic hypothesis, remarking that the gaseous hydrocarbons present in volcanic eruptions might easily become absorbed and stored up in porous strata of the earth's crust, so as to form eventually deposits of crude oil, supporting his view by the undoubted connection found between large deposits of oil and lines of geologic fracture.

He holds that the great deposits of oil in the Tertiary strata are found around the circumference of the great Secondary and Tertiary geocynclinal, along which have risen the great recent mountain chains like the Alps. And this zone of folds coincides with the volcanic zone which marks the end of the Tertiary era.

Furthermore, the strongest argument of those who hold to the theory of an organic origin, namely, the frequent association of beds of oil and gypso-saline strata, can readily be explained by the volcanic hypothesis, since the distribution of the oil beds of Neogenic eras, lends itself admirably to the theory of volcanic emanations which have traversed geologic strata, along the lines of the great fractures; and since moreover, the movements of sea-coast lines at the time of the formation of the Tertiary chain must have favored the formation of lagoons along the borders of these great Tertiary reliefs.

On the whole, therefore, in spite of the admirable work published in support of the organic hypothesis of the origin of petroleum, M. Gentil is strongly disposed in favor of the mineral theory of its formation.

Testing Explosives Force with the Piezometer*

Pressure-Electricity Produced in Crystals by the Explosive Gases of Guns and Motors

AMONG the most beautiful and interesting objects found in nature are crystals of various kinds, some of them including, of course, very rare and beautiful gems. Crystals, moreover, are peculiarly interesting to men of science, because of their very remarkable characteristic properties. Many of them, for example, have the faculty of polarizing the rays of light which fall upon them and this phenomenon has long excited special attention among physicists. Most interesting of all, perhaps, are crystals of tourmaline and of quartz, which are not only utilized for special purposes in laboratories of physics but have certain valuable industrial applications.

Tourmaline consists, from a chemical point of view, of certain fluoriferous boro-silicates united with alumina in which other minerals are found, particularly magnesia and iron and including manganese, lime, potash and soda with lithine at times, and even traces of phosphoric acid in many cases.

Regarded from its physical aspect tourmaline exhibits rhombo-hedric prisms having from six to nine plane surfaces, but often posssesing a triangular section which recalls a spherical triangle. The color is various, for which reason it furnishes many particularly beautiful jewels to the world of trade; these different colors depend, of course, upon the nature and percentage of the mineral constituents and include numerous shades ranging through black, dark and light brown, green, blue, red, pink, "dregs of wine"; sometimes, too, a single specimen shows several colors.

It is found in various parts of the world—in Siberia and in Brazil, in Sweden and in Greenland, in the Hartz Mountains and within the bowels of Mount St. Gothard, in Cornwall and in Massachusetts, and even in "Elba's Isel." It occurs in granite, in gneiss, in syenite, in chlorotic schists or talc schists, in dolomite, in crystalline lime stones, etc. Quartz is likewise a rhombo-hedric crystal. It is a crystal of silica and is found in very numerous varieties having distinct forms and colors according to the nature and amounts of the foreign matters incorporated with the crystal. It, likewise, is of very widespread occurrence.

Both tourmaline and quartz have a common crystallographic characteristic, namely, that of being hemi-hedric. In other words, they escape that law of symmetry which controls the majority of crystals; thus crystals of tourmaline commonly appear to be prismatic columns terminating at the top and at the bottom by systems of faces which are non-symmetrical; to this fact is due their peculiar behavior with respect to rays of light.

Hemi-hedric crystals—or at any rate those among them which have inclined faces—differ from ordinary or holo-hedric crystals in the possession of the very curious potentiality known as pyro-electricity.

Pyro-electricity.—This property was first observed in tourmaline more than 300 years ago; in 1703 a Dutch observer had occasion to heat crystals of tourmaline for some purpose or another upon a brazier. While they were cooling he was surprised to observe that they exhibited a power of attracting light particles of various sorts. This observation was published in a treatise which appeared in Germany in 1707 and thereafter tourmaline became known as the electric stone or the Ceylon magnet.

Recent authorities have come to think it probable, however, that this property was known even to the ancients. Pliny, for example, has an allusion to "certain minerals which attract light bodies when they are subjected to solar rays or to friction." And it is supposed by Poggendorff that these minerals termed *carbunculus* by Pliny were really fragments of tourmaline.

However, the electrification of tourmaline by heat is an entirely different phenomenon from that exhibited in electrification by friction—in the latter one of the two bodies rubbed against each other is electrified positively and the other one negatively, whereas when tourmaline is electrified it is charged with both kinds of electricity at one and the same time.

By the process of heating there takes place in the case of the tourmaline a dissociation of the two kinds of electricity in the same body, and there is produced between the extremities of the latter a difference of potential, or, in other words, an electro-motive force just as in the case of an electric or thermo-electric battery, although in the former case a homogeneous system is concerned instead of a group of different substances.

This phenomenon can be exhibited in a very simple manner by heating tourmaline crystals in any sort of stove or furnace removing them and sifting upon them, while still hot, a mixture of fine powder composed of minium and sulphur through a muslin sieve. It is this mixture of red lead and sulphur which is employed in the well-known experiment by which the so-called Lichtenberg figures are produced. It is known to scientists that the two powders become electrified through friction against each other, the former positively and the latter negatively; when they are allowed to fall upon the crystals of tourmaline the sulphur is found adhering to one end of the crystal which indicates, of course, that the latter is positively electrified, while the minium clings to the other end of the crystal, showing this to be negatively electrified.

At a later date a closer study of this pyro-electricity brought out the fact that the electrification in question is closely connected with certain elongations and contractions to which crystals are subject. In 1885 Professor Cuire discovered that these phenomena are subject to the great *law of reversibility*, in such a manner that electrification is excited by tension and compression; thus tension exerted upon a crystal of tourmaline in any given direction produces the same effect as heating it, while pressure upon the other hand exerted upon the crystal corresponds in results to cooling it. This law holds good with quartz also.

The phenomenon of piezo-electricity or pressure electricity can also be very simply demonstrated by taking a crystal of tourmaline, as large as possible, and splitting a lamalla from it by a cleavage perpendicular to the principle axis, *i.e.*, the axis running from the base to the summit; upon this sheet of tourmaline there is then placed a sheet of brass connected with an electrometer, while upon the brass there is then placed a weight. When this weight is pressed downward by the hand the electrometer is seen to deviate in a certain direction, while if the sheet of tourmaline be reversed the deviation of the electrometer changes its direction, thus indicating that there has been an inversion of the polarity.

This experiment can be performed in the same manner with quartz instead of tourmaline, but whereas in the case of the latter the piezo-electricity is exhibited only when the pressure exerted is perpendicular to the faces, it is exhibited in quartz also through pressures exerted upon the sides. Professor Cuire proved through his study of the laws of this phenomenon that the *quantity of electricity produced is directly proportionate to the pressure.*

Since Cuire's researches a number of physicists have devoted extensive study to the problems here involved. Boigt has indeed, devoted an entire book to them. It has been established that the crystals in question possess definite electrical axes, along which the pressure applied must be exerted in order

*Translated for the *Scientific American Monthly* from *La Nature* (Paris), for Jan. 8, 1921.

to produce the maximum effect. The latter is produced upon the faces normal to the electrical axes along which the pressure is exerted; upon these faces there can be collected quantities of electricity equal in amount and of contrary size.

The quantities of electricity obtained, q, are proportional to the surface S upon which the electricity is collected, to the pressure P exerted per unit of surface, and to a coefficient x K, which is termed *the piezo electric constant.* These facts can be expressed in the equation $q = KPS$; if q be expressed in CGS units, P in grams per square centimeter, S in square centimeters, then the piezo-electric constant of quartz is $K = 6.45 \times 10^{-8}$ while that of tourmaline will be $K = 5.71 \times 10^{-8}$. (These figures are taken from the list of *Physical Constants*, published by the French Society of Physics.

As we see from the above figures the quantities of electricity thus produced are extremely minute and in spite of the great scientific interest of the phenomenon it was not supposed to be capable of any sort of practical application. Such an application, however, has recently been proposed by the well-known physicist, J. J. Thomson, for the purpose of measuring the degree of pressure produced by explosive forces in fire arms and in explosion motors.

In these engines the pressures are developed in extremely brief intervals of time so that it is very difficult to measure them by means of ordinary mechanical processes. This can be done, however, very beautifully through the phenomenon described above of pressure electricity in tourmaline or quartz, through the device invented by Thomson.

Upon each of the two opposite faces of a sheet of tourmaline a leaf of brass foil is placed; these two leaves are connected with two metallic plates mounted in a vacuum tube; the crystal between these two sheets or leaves of metal is then placed within the medium whose variations of pressure it is desired to examine. Under the effect of the exposure the crystal becomes electrified and produces a difference of potential between the electrodes of the tube.

The problem now is to observe this difference of potential; for this purpose there is sent between the plates of the tube a flux of electrons produced by a metal filament, heated electrically and placed in a compartment of the vacuum tube which communicates by means of a very narrow channel with the principal chamber within which the two electrodes are placed; at the end of the tube, opposite the filament, there is placed a photographic plate or a screen.

So long as the tourmaline is subjected to no pressure the difference of potential between the plates of the tube is nil, and since the flux of electrons remains rectilinear it strikes the screen in the center; but as soon as any pressure is produced the tourmaline is electrified and a difference of potential takes place between the plates thus causing a deviation in the flux of electrons.

The object of this is to interpret the images thrown on the sensitive plate or screen and for this purpose to prevent them from being superposed; it is not possible to displace the plate within the tube; the solution indicated by Thomson consists in imparting to the flux of electrons itself a definite movement by subjecting the said flux to the action of an alternating magnetic field.

This ingenious idea has already produced interesting results from the observation of the photographs thus made by Mr. Thomson, who expressed the hope, in an address delivered a few months ago, that the device might prove to be of use in various directions. Mr. Thomson also suggested that it may be possible to substitute quartz for tourmaline in such experiments, or even crystals of cane sugar. It may likewise be possible to substitute much simpler and easier methods of observation, such for example as those employed in the case of the tubes emitting electrons which are now in use in the fields of wireless telegraphy and telephony.

An even more interesting realm of experiment in this connection, however, has been recently opened up by the American physicist, A. McLean Nicolson, in his researches on the pyro-electric and piezo-electric properties of other classes of crystals. This investigator has made a special study of crystals of potassium tartrate and sodium tartrate, which have the advantage over quartz and tourmaline of being easily prepared in the laboratory and of attaining dimensions of considerable size.

Sodico-potassic tartrate is well known in commerce under the head of Rochelle salts, or Seignette salts, the latter term being due to its discovery in 1672 by a pharmacist, Pierre Seignette, living at La Rochelle. Its chemical formula is

$$C_4H_4O_6NaK + 4H_2O$$

It is obtained by saturating potassium bi-tartrate with potassium carbonate; 12 parts of water are brought to the boiling point and 4 parts of cream of tartar and 3 parts of crystallized carbonate of soda are added; the solution is filtered, evaporated and allowed to cool, the handsome crystals obtained being purified by recrystalization.

ELECTRIC STEEL INDUSTRY

The net increase in the number of electric furnaces in the United States last year has been 33 as against 36 in 1919; 54 in 1918; 97 in 1917; and 63 in 1916. The total is now 356 as against 323 on January 1, 1920. The expansion of the industry is appreciated when it is recalled that there were only 19 furnaces of all types in the United States on July 1, 1913. In Canada the industry is virtually at a standstill. As heretofore the Heroult furnace maintains its leadership in installations and output. Most conspicuous in the progress of the American steel industry last year were the Greene and Greaves-Etchells types. Expansion in the installation of other types have either been small or nothing. A new furnace of small size but of decided interest and practical use is the Von Schlegel repelling arc furnace sold by the Industrial Electric Furnace Company, Chicago. This furnace was described in *Iron Age* for Dec. 9, 1920. Only one of them is operating in the steel industry, but about six are in use in the non ferrous industry. Data regarding the Moore electric furnace and one known as the Volta were not obtainable, except from current news sources. The Volta furnace sold by the Volta Mfg. Co., Welland, Ontario, is an outgrowth of the war. It is the furnace which was developed by Robert Turnbull, now general superintendent of the United States Ferro Alloy Corporation, Niagara Falls, N. Y. It is understood that the United States has been invaded by this furnace and that two are being installed near Pittsburgh.

The world's steel industry as a whole is credited with 961 furnaces of which the United States and Canada are credited with 399 or over 40 per cent. The number of furnaces in the other leading countries are as follows: England, 150; Germany, 100; France, 69; Italy, 50; Sweden, 50; and Norway, 20. The gradual and healthy expansion in this industry in 1920 is an assurance that the United States will continue to hold the supremacy over Germany and all other countries which it wrested in 1916 and which it has held since—both in number of furnaces and in production.

EARTH-CURRENT TELEGRAPHY

A system of earth-current telegraphy was somewhat extensively used by the Allied Armies during the war.

At the transmitting station, an insulated wire, some 50 to 70 yards in length, is laid along a trench and carefully earthed at its ends. Intermittent currents are passed along this wire, and corresponding but very feeble currents are picked up between the similar earth connections of the receiving apparatus. A vibrator of particularly substantial construction, giving audible frequencies, is used in series with a Morse key, and the currents are picked up by a telephone in the receiving apparatus, after having been amplified by one or more thermionic amplifiers. With a current of 0.5 ampere and a three-stage amplification the working range is 1½ to 2 miles, and in exceptional cases, nearly 7 miles.—*L'Industrie Electrique*, Jan. 10, 1921. Abstracted by *The Technical Review*.

A New Physical Phenomenon*

Utilizing the Electrical Attraction Between a Conductor and a Semi-Conductor

The following is an abstract of an exceedingly interesting paper which was read at the City Hall of Copenhagen last August before a distinguished audience of scientists at the celebration of the 100th Anniversary of the birth of H. C. Oersted, the Danish scientist who discovered Electromagnetism. The paper describes a new discovery, capable of a number of applications which the inventors demonstrated by means of experiments.—EDITOR.

TWO Danish engineers, Mr. A. Johnsen and Mr. K. Rahbek, have been occupied during the past two years with the endeavor to discover a practical application for a new physical phenomenon recently discovered by them, which may be stated as follows:

When a sheet of gold leaf is attached to one side of a lithographic stone and a sheet of brass is placed against the opposite smooth side of the stone, and the gold leaf and the sheet of brass are connected with a direct current of 220 or 440 volts, the brass will cling tightly and with great force to the stone. When the current is interrupted, the stone and the brass will fall apart. This phenomenon is to be explained in the following manner:

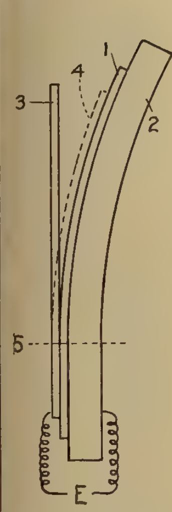


FIG. 1

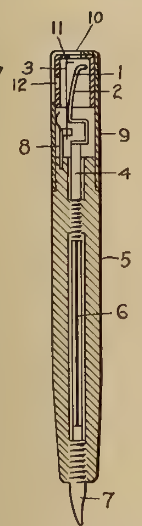


FIG. 2

The potential between the gold leaf and the sheet of brass is distributed through the semi-conductor, the stone, with a comparatively insignificant drop, so that the potential on either side of the very small air space separating the stone and the brass becomes great, disclosing the existence of great forces.

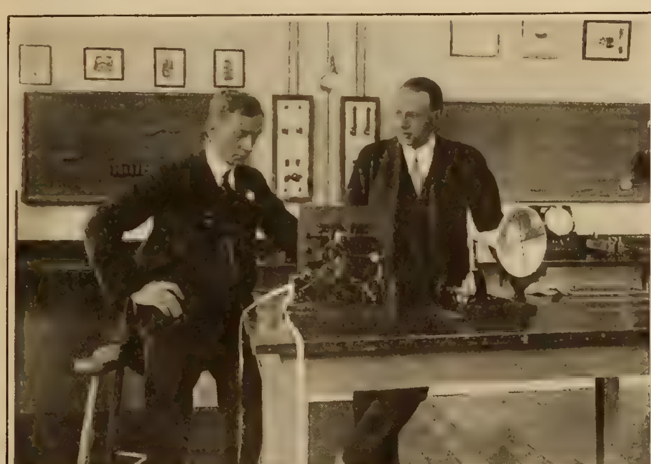
In order to make use of this phenomenon for technical purposes, the two inventors have employed the well known principle applied in brakes where a band slides on a rotating drum. For this purpose a gelatin band is used with one end attached to a telephone diaphragm and passed over a rotating metal drum to a spiral spring so arranged as to hold the band tight against the face of the drum. When a current of electricity passes from the spiral spring through the semi-conductor (which is in this case the strip of gelatin) to the rotating drum, the variations in the current will produce a greater or less degree of adhesion of the gelatin strip, and the greater or less degree of friction thus occasioned will have the effect of producing a corresponding variation of pull on the telephone diaphragm.

In order to make use of this discovery in a loud speaking telephone, the latter is connected in series with a battery in the secondary of a transformer, so that there will be produced a direct current of varying strength. Instead of a telephone diaphragm, the sounding board of a violin can be employed for the reproduction of music. The phenomenon has also been applied to the recording of wireless waves which are amplified by an audion and also rectified by the same to a direct current of varying strength. Upon the principle just described is based a recording apparatus which registers the variations in the current upon a strip of paper. In this instrument a rotating agate drum is used, and on the circumference is a metal band under the influence of the variations in the current. A stylus records the movements of the band on the strip of paper, forming a wave line, comparable to telegraphic symbols. By means of this apparatus it is possible accurately to transcribe wireless telegrams at a speed of 300 words per minute.

An electroscope has been constructed which works upon the same principle and is intended to detect faulty lamp sockets, switches or other parts of electrical installations. Examinations can be made by means of this apparatus without test wiring or special preparations. This apparatus will undoubtedly, like the fountain pen, meet a long-felt want, on account of its being highly sensitive and the ease of carrying it in a pocket.

Fig. 1 shows the principle of the apparatus. Here *1* is the semi-conductor, which in this case consists of gelatin spread in a uniform layer over and in intimate contact with the slightly curved conducting sheet of metal, *2*. One pole of the current is connected to the metal, while the other pole is connected to an elastic, slightly curved, conducting strip of aluminum foil, *3*, whose lower end is steadily pressed against the semi-conductor *1*, so that the flat surfaces of the foil *3* and the semi-conductor *1* (which face each other) will come in contact with each other on a tangent approximately along the line *5*.

If the potential between the sheet of metal *2* and the metal foil *3* is of suitable amount that part of the foil *3*, adjacent to section *5* where the air space is inappreciable, will be attracted with great force toward the gelatin covering of the sheet metal. The force is so great that it will overcome the elastic resistance against bending. As the foil gradually bends toward the gelatin layer, the source of power moves upward with the result that the entire metal foil *3* is placed, by a rolling motion, snugly against the gelatin layer in position *4* as indicated by dotted lines in Fig. 1. The fact that the uppermost end of the foil *3* has the greatest amount of motions is utilized in the practical application of the apparatus for indicating a difference of potential.



MESSRS. JOHNSEN AND RAHBEK DEMONSTRATING THEIR AMPLIFYING APPARATUS WITH WHICH RADIO SIGNALS ARE RECORDED ON A PAPER TAPE

If the connection with the source of the current is broken, the foil will linger in the position *4* shown in Fig. 1 and will not come back to the original position *3* until the potential by the gradual discharge through the semi-conductor has decreased to such an extent that the elasticity of the foil *3* is able to overcome the force of attraction. The semi-conductor may be so chosen in respect to conductivity as to cause the

*Translated for the *Scientific American Monthly* from the *Elektroteknisk Tidsskrift* (Copenhagen) for October 20 and December 20, 1920, Nos. 30 and 36.

discharge to vary from a fraction of a second to several minutes. If the current between the sheet of metal *2* and the foil *3* be short circuited, the conducting foil will at once straighten out.

Fig. 2 shows in cross section a practical application of this apparatus. In this figure the metal sheet *2* is bent in the manner indicated and is covered on the left hand side by a layer of gelatin *1*. The metal sheet is fastened to the metal upright *4* which is screwed to the ebonite tube *5*. The metal sheet is connected through the metal upright and through a graphite resistance *6* of ½ megohm with the metal point *7*, which projects from the jacket *5*. The curved foil *3* is conductively connected to the upper metallic part of the jacket *9* by means of the curved contact spring *8*. Now when one wishes to ascertain if a certain potential exists between a conductor and the ground, the upper part *9* of the jacket is held in the hand and the metal point *7* is brought in contact with the conductor or the particular part of the installation in question. If there is a current in the conductor, the metal foil *3* will roll over as shown in Fig. 1, and the red mark *11* painted on the metal foil *3* will come to a position in front of the window *10*. The apparatus is so sensitive that it does not matter whether the person making use of it has a good connection with the ground or not; he may for instance be standing upon a wooden ladder. In certain circumstances where the red mark cannot conveniently be observed and when the electroscope has a perceptable period of discharge, the motion of the metal foil can also be observed through the window *12*.

As a result of the fact that the resistance *6* is very great, the operator runs no risk of receiving an electric shock in case of a short circuit through the substance of the gelatin.

The metal foil can be made heavy enough for the apparatus to bear transportation and to bear handling in any position, because strong electric forces are active in the apparatus. On the other hand its sensitiveness is so great as to indicate reliably a potential of 220 volts.

The apparatus can be used quite as well for an alternating current, as for a direct current.

THE ELECTRICAL EXPRESSION OF HUMAN EMOTION

In a discourse delivered on February 4th, before the Royal Institution, Dr. A. D. Waller, F.R.S., director of the Physiological Laboratory, University of London, dealt with the invisible and insensible manifestations of emotion which accompany visible responses such as muscular movements and secretory discharges. Dr. Waller at once proceeded to demonstrate the phenomena which he has been investigating during recent years and which were first described as psycho-galvanic reflex phenomena, by Veraguth (Berlin) in 1909. Dr. Waller's first subject was a "normal person," a medical man. Electrodes (zinc disks covered with chamois leather impregnated with salt solution) were strapped to his hand and coupled in series with a battery of a few cells and a galvanometer, so as to form one arm of a Wheatstone bridge. Another pair of electrodes in circuit with another galvanometer was attached to the forearm. The two light spots were marked *H* and *A* respectively. Bridge balance having been established, Dr. Waller threatened to prick the subject with a pin; *H* was deflected, marking a decrease in resistance, and was again deflected, but rather less strongly, when the pin was really applied after a while. The *A* galvanometer took part in these movements, but the deflection was merely a slow creeping movement. Similar observations were made when the lecturer lighted a match to burn the subject, and when he spoke of blowing a motor horn. The suggestion of the pain or noise had a more marked effect than the actual application of the test. The response was thus not under our control—though this statement had to be qualified—and that made these tests valuable for discovering cases of malingering.

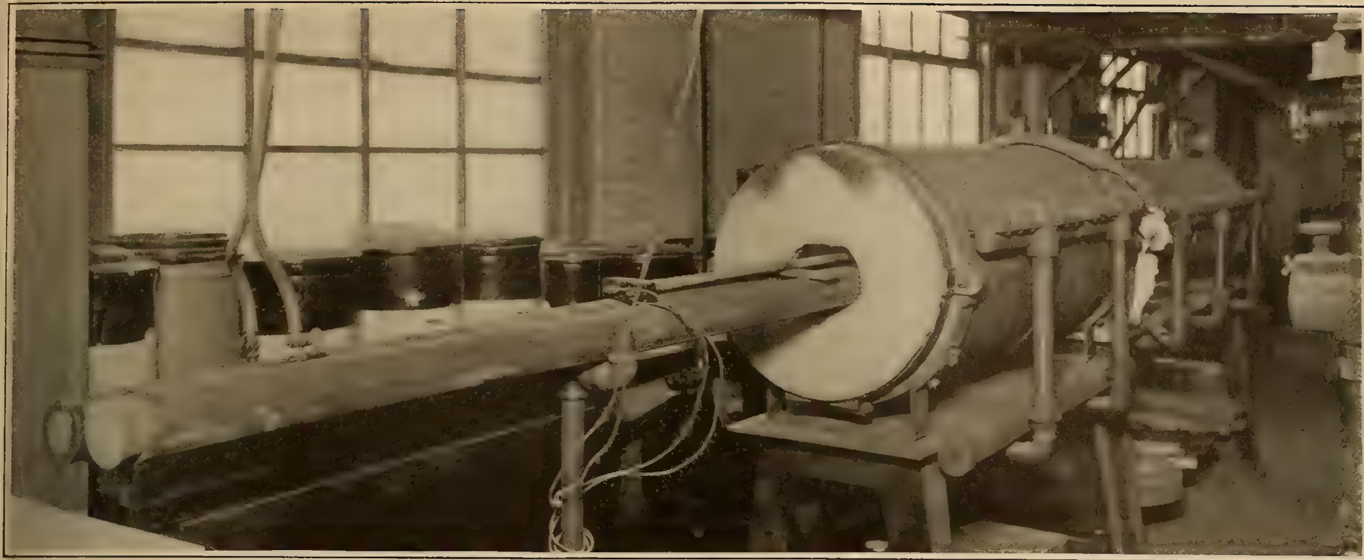
Dr. Waller showed, however, that people are not all equally sensitive in these respects. The four spiritualistic mediums whom Dr. Waller had been able to examine had proved remarkably sensitive; in their case both the *H* and *A* would respond almost equally and at the same moment. Dr. Waller exemplified this at a later stage with another subject whom he would class with the highly sensitive or imaginative people. Most men and women were normal and gave the palmar response H, but hardly any forearm *A* response; in them the response to fiction was greater than the response to the fact. He had also found insensitive people giving neither response, among psychiatric and shell-shock cases. Dr. Waller remarked that he thought he could distinguish a true medium from a false medium by his tests.

Confirmatory evidence was adduced by a great many photographic slides which also showed by their time scale, what the demonstrations had made quite striking, that the electric response is not instantaneous with the emotion, but follows it after a distinct lag or one, two or more seconds. The slides further gave the myograph, the curve of muscular activity. When the subject had raised the finger, the muscular contraction was at once recorded by an increase in electric resistance, while the emotional decrease in resistance lagged behind.

In general the hand or palmar response was more rapid than that of the foot, and the foot more responsive than the leg, but the latter did not hold for very sensitive people. Most of the curves were very jagged, the galvanometer coming to rest after rapid oscillations. As the measurements were resistance determinations, and as the palm of the hand proved the most responsive part of the body, Dr. Waller had taken continuous observations of his palmar resistance. He then observed fairly regular diurnal variations of the resistance, the resistance being greater at night than during the active hours of the day, and that variation seemed to run parallel with the emotional activity. In order to decide whether the diminution of the resistance following and marking emotion was a real decrease of resistance or due to some electro-motive force (a diminution of the e.m.f. of polarization) he also placed a potentiometer in series with the bridge arm. These experiments showed that there was a real diminution of the resistance.

Dr. Waller hence came to the conclusion, a few years ago, that the emotional response depended upon the dilatation of the membranes through which the ions pass in general vital activity. When the nerve impulse reached the membrane, the protoplasm contracted, and the pores became dilated (somewhat as the pupil dilated), so that more ions could pass and more carriers of the current entered into action. By watching a galvanometer in the palmar circuit one could see oneself live, in a sense. During the active hours of the day the pores were more dilated; at night, and when we were fatigued, the pores contracted. Any discharge in the nerve system, whether emotional or not, thus gave rise to galvanic phenomena. That was in accord with the palmar resistance measurements mentioned and with other observations. The response of the right hand was more intense than that of the left hand, but the curves were parallel. Hand and foot mostly went parallel as well, but when the hand response lagged two seconds behind the emotion, the foot response might lag by four seconds. The dilatation of the pores itself was not instantaneous, requiring about two seconds to become effective. Various observations made during the air-raids of the war brought out some curious facts. In one case the maroon signal and the anti-aircraft guns had not produced any effect, but the hum of the Gotha was marked by a strong deflection, corresponding to a resistance-decrease of about 4,000 ohms, much greater than in the laboratory experiments. A certain control seemed therefore possible.

We should add that Dr. Waller offered his explanation of the phenomena as merely a working hypothesis, not yet as a theory.—From *The Electrician* (London), February 11, 1921, p. 202.



HYDROGEN FURNACE FOR THE REDUCTION OF TUNGSTEN AND MOLYBDENUM

Industrial Applications of Hydrogen

The Many and Widely Varying Uses to Which This Gas Is Being Commercially Put

By Harry L. Barnitz, Ph.G.

THE industrial application of hydrogen generally speaking has only been brought about in the last decade. New processes wherein hydrogen will be required in large or moderate quantities are continuously and rapidly being developed, due to extensive research at the present time conducted in the laboratories throughout the world. No element today is receiving more study than the industrial production and application of hydrogen, and it is anticipated that many remarkable discoveries for its industrial use will be announced.

In the hydrogenation of oils, hydrogen has found its greatest applicability up to the present time and this development will employ even greater quantities than heretofore, as the industry is as yet in its infancy. In the immediate future hydrogen no doubt will find its greatest application in the production of synthetic ammonia, liquid motor fuel and further extended uses in metallurgy.

The commercial applications of hydrogen in the processes to be described are those which were developed practically during the last decade and up to the present time and are impressive as to its possible, enormously extended, industrial use in the future.

THE SYNTHETIC PRODUCTION OF AMMONIA

The discovery of the synthetic production of ammonia by Professor Haber[1] of Karlsruhe a few years ago promises a very extensive use for hydrogen. It is of immense importance inasmuch as it forms the basis of the well-known fertilizer, sulphate of ammonia. When hydrogen and nitrogen are heated at 600° to 700° C., in their combining proportions, under a pressure of about 20 atmospheres and in the presence of uranium as a contact substance they unite to form ammonia; about 6 per cent of ammonia is produced and by removing this a further conversion is effected. Very recently the yield has undoubtedly been greatly increased and the process accelerated by the selection of a possibly more suitable contact substance and the application of possibly more appropriate temperature and pressure.

[1]This process was used on a large scale by Germany during the war in connection with the manufacture of explosives.

Nitrogen and hydrogen directly unite to form ammonia under proper conditions as indicated by the equation:

$N_2 + 3H_2 \rightleftarrows 2NH_3$

1 vol. 3 vol. 2 vol.

Heat evolved as indicated by the equation:

$N + 3H = NH_3$ (gas) ÷ 11,900 calories = 727,000 B.t.u. per sq. ton S./A

The above equation is reversible, depending upon the equilibrium represented by the expression:

$$K = \frac{P_{NH_3}}{P_{N_2}^{1/2} \, P_{H_2}^{3/2}}$$

where P_{NH_3}, P_{N_2}, P_{H_2} represent the partial pressures of the respective gases NH_3, N_2, H_2 and K is the reaction constant. As noted, 4 volumes of the mixture of nitrogen and hydrogen produce two volumes of ammonia and therefore, as in the case of all gaseous reactions where the products of interaction occupy a smaller volume than the original components, an increase of pressure favors the formation of the products possessing the least volume. Works for the production of synthetic ammonia by this process on a large scale have been erected at Oppa, near Ludwigshafen by the Badische Aniline und Soda Fabrik. No information as to details of the method have been made public of the process as worked in a commercial plant. However, details of Haber and Le Rossignol's experimental plant have been published. Fig. 1 is a sketch of Haber and Le Rossignol's experimental apparatus.

Passing through the tube *F* a mixture of 1 vol. nitrogen and 3 vols. of hydrogen under a pressure of 200 atmospheres enters the strong steed vessel *MM*. After passing over the outer surface of a number of capillary metallic tubes *W* which serve as a heat interchanger and regenerator which is explained later—the gas passes through the tube as shown, over the surface of an electrical heating coil *AA*, where the temperature of the gas is increased to 800°-1,000° C., then back up an interior iron tube *S*, over the layer of catalytic substance *B*, thence through a number of capillary tubes *W*, out through the tube *X*, thence through the compressing pump *P*, working

at 200 atmospheres pressure, thence out through the tube *E*, through the set of capillary tubes *X*, and so into the vessel *H*, which is surrounded by a freezing mixture of solid CO_2 and ether at a temperature of 60° or 70°, which causes the ammonia in the gas to separate in the liquid state whence it can be drawn off by the cock *J*. From *H* the gases pass away by the tube *F* over the exterior surface of the system of capillary tubes *X*, thence after passing over a soda-lime drier *K*, the gas enters *M* as previously described.

The cold gas entering *MM* by the pipe *F* is heated by passing over the bundle of capillary tubes *W* conveying the hot gas away from the contact substance *B*. Thus the entering gas is, by the time it has left *W*, preheated to a temperature of 400° to 500° C., and in so doing has abstracted practically all the excess heat from the hot gas passing away from *B*, so that this latter, by the time it reaches the pipe *X*, is practically at atmospheric temperature, while at the same time the entering gas, by the time it reaches the heating coil *A*, is already at a high temperature, so that practically no loss of heat occurs. For this reason *W* is called the "heat regenerator." The hot gas thus entering the tube *SS* is further heated in its passage by the electrical heating coils surrounding the end of the tube *SS* to a temperature of 800° to 1,000° C. The hot gas then passes into the contact substance *B*, which is maintained by the hot gas at a temperature of 500° to 700° C. Here the formation of ammonia takes place, 3 to 7 per cent of the entering nitrogen and hydrogen escaping as NH_3 along with the excess of uncombined nitrogen and hydrogen. The hot mixture of gases from *B* then streams through the series of fine capillary tubes *W*, and in so doing gives up practically all its heat to the cold entering stream of gas coming into the apparatus at *F*. The gaseous mixture, now cooled to ordinary temperatures, passes away through the pipe *X*, into the pumps *P*, working at 200 atmospheres, and then passes through the series of capillary tubes *X*. While passing through there it meets with a cold stream of gas at 60° C. coming from the vessel *H*. Consequently, the gas in the capillary tubes *XX* parts with its heat *L*, the cold gas coming from *H* being itself chilled in so doing, and passes out of *X* through the pipe *DD* into *H* at a temperature only slightly above that of the cold gas escaping from *H*. The cold gas passing from *H* up *F* is heated almost up to atmospheric temperature by the capillary tubes *X*, and thus passes away through the drier *K* and enters *MM* at *F* at a temperature only slightly below atmospheric. For this reason the tubes *X* are called the "cold regenerator."

The gas entering *H* contained 3 to 7 per cent of NH_3, and this condenses in a liquid form at the low temperature (—60° C. to 70° C.) prevailing therein, owing to the surrounding freezing mixture of solid CO_2 and ether. This ammonia can be drawn off in a liquid form by the tap *J*, or, if required in a gaseous form, can be so obtained by opening the outlet valve to a suitable extent.

As the ammonia is withdrawn a fresh supply of nitrogen-hydrogen is added through the valve *O*, so that the operation is a continuous one.

PRODUCTION OF ALCOHOL

Alcohol is now being produced for industrial purposes from calcium carbide through treatment with hydrogen. No detailed working description has been announced, but a general outline of the process has been published recently which is as follows:

"Acetylene is passed through acidulated water containing a mercury salt, whereby acetaldehyde is formed; the latter is vaporized, mixed with hydrogen and the mixture passed over a nickel catalyst, when alcohol results. Alternatively acetaldehyde is converted into acetic acid by passing the vapor, mixed with oxygen, over a nickel catalyst. It is stated that a plant is being built near Visp in Wallis, Switzerland, capable of an annual production of 100,000,000 kg. alcohol by this process, this being sufficient to cover the whole requirement of Switzerland."

PURIFYING OILY MATERIALS

Deodorizing fatty oils by treatment of hydrogen has been known for some time by those operating the hydrogenating process, in which identical results are obtained in the presence of a catalyzer. Hydrogen treatment in the process of purifying fatty oils is one which is accomplished in the absence of a catalyzer and does not affect its physical character—in other words it remains liquid whereas in the presence of a catalyzer the oil becomes hard.

It is claimed that deodorizing oils by hydrogen is superior to the steam deodorizing process for certain vegetable and fish oils and that their keeping qualities remain sweet for a longer period.

The method of deodorizing any oil or fat by this process consists of blowing hydrogen, or a gas whose principle constituent is hydrogen, through the heated oil and allowing the hydrogen with the entrained vapors from the oil to escape freely from the containing vessel until the desired result is obtained. In the commercial application of this process, the

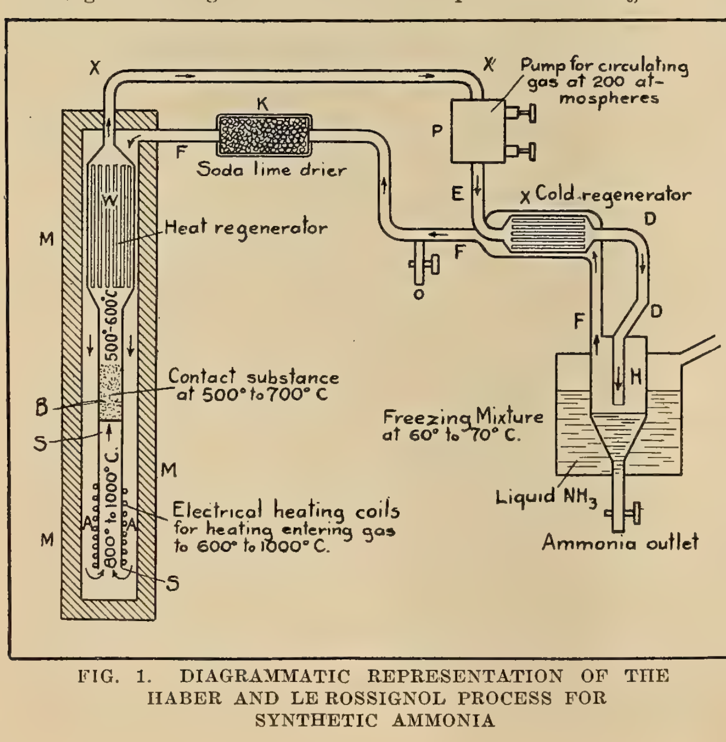


FIG. 1. DIAGRAMMATIC REPRESENTATION OF THE HABER AND LE ROSSIGNOL PROCESS FOR SYNTHETIC AMMONIA

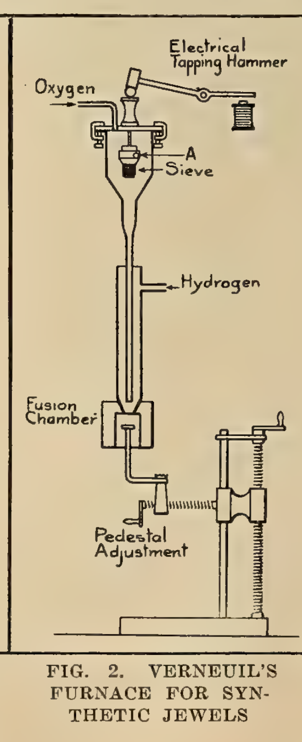


FIG. 2. VERNEUIL'S FURNACE FOR SYNTHETIC JEWELS

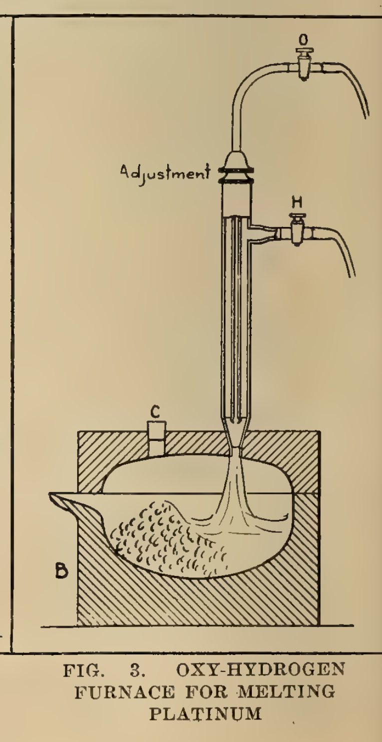


FIG. 3. OXY-HYDROGEN FURNACE FOR MELTING PLATINUM

USING THE OXY-HYDROGEN FLAME FOR MELTING AND FORMING ARTICLES OF FUSED SILICA

fatty acids and other fumes are condensed and washed from the hydrogen, which is thus completely purified and used over again. The entire apparatus should, of course, be filled with hydrogen to the exclusion of all oxygen from the air at the time of its first use. Thereafter, each new batch of oil is introduced and the deodorized oil withdrawn through pipes so that no air enters the apparatus. A means of drying the hydrogen is provided in the gas-purifying system if the oil being treated contains appreciable quantities of water.

The means whereby the deodorization is accomplished in this process are both chemical and physical. The iodine value of the oil treated is lowered to a certain extent and the amount of lowering is proportional to the original iodine value. It is claimed that the process can be successfully operated when the oil comes in contact with nothing but glass and hydrogen during treatment.

SYNTHETIC PRODUCTION OF JEWELS

Practically all of the beautiful minerals of the corundum family are now being produced synthetically. The ruby and the sapphire are the more important.

Alumina being the base of these precious stones, it remains only for the chemist to add the proper oxide to obtain the required colors and to fuse them together in the oxy-hydrogen flame. The ruby, for example, contains 97½ per cent of pure alumina and about 2½ per cent of chromic oxide.

It is absolutely essential that the material be pure, as otherwise the product obtained will be faulty and the color will be poor.

The process is as follows:

Pure iron-free ammonium alum $(NH_2)_2SO_4$. AL_2 SO_4 $.24H_2O$, is mixed with a little chrome alum $(NH_4)_2SO_4$. CR_2 $(SO_4)_3$ $.24H_2O$, and the whole precipitated in warm aqueous solution by means of ammonia. A mixture of $AL(OH)_3$ and $CR(OH)_3$ (2½ per cent CR_2O_3 gives the best color) is thus obtained.

At a temperature of 1,000° C., the material is calcined in an oven at a bright red heat and removed and reduced to a fine powder. The fine powder is then placed in the magazine (Fig. 2) which then passes through a platinum sieve situated in the oxygen tube of the oxyhydrogen furnace, and then forced down on a receiving base below the flame. The work at this stage is very delicate and requires most careful attention. All conditions must be regulated with mathematical precision; the rate of the flow of the AL_2O_3 powder, which is automatically controlled by an electric magnet; the rate and pressure of the gases; and the quality of the flame 2.537.78° C. With conditions properly adjusted the stone at first appears as a little stalk not larger than a pin head as seen in Fig. 4, which gradually grows in the fire. This stalk, as it grows taller, is broadened by the manipulation of the torch by a skilled operator so as to form a small cone with the point down, *E*. The desired size obtained, the operator shuts off the

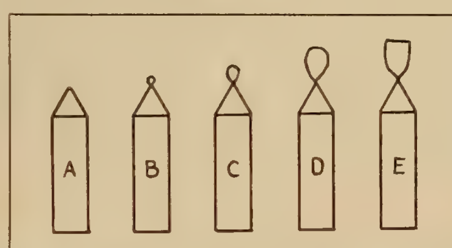


FIG. 4. PHASES IN THE MAKING OF THE RUBY
A, cone of Al_2O_3. *B* pin head, *C* and *D* enlarged boule. *E* jewel formed and ready for cutting

gases and cautiously allows the jewel to cool. It is then broken from the base and is ready for cutting.

The specific gravity is 3.98 to 4.0, hardness; optical properties, and general character agree with natural rubies.

White sapphires are formed by the omission of the chromium and are pure alumina, AL_2O_3.

BLUE SAPPHIRES

Blue sapphires are made by adding 0.5 per cent titanium dioxide, TiO_2, and 1.5 per cent magnetic oxide of iron, FE_3O_4; the analysis being

AI_2O_3, 99.84 per cent
TiO_2, 0.11 to 0.13 per cent
FE_2O_3, Trace
Specific gravity 3.977 to 4.01.

Rubies and sapphires besides being used as gems have a very extended use in watches, phonographs, balances, and in delicate mechanism which require hard unwearable smooth surfaces.

HYDROGEN EMPLOYMENT IN QUARTZ GLASS OR FUSED SILICA GLASS

Quartz glass (SiO_2) which has long been recognized as an important material in the manufacture of various articles employed in the chemical industry, was first produced in 1839 by Professor Gaudin. Some of his quartz tubes and elastic threads were exhibited at the Paris Exposition in 1878.

In 1889, Boys, who recognized the possibilities of this remarkable substance, also succeeded in making small tubes and other articles.

However, little progress was made in the development of the quartz-glass industry until 1900, when Heraeus and Achendstone succeeded in making clear rock crystal large enough for practical purposes. The raw material is washed quartz sand containing 95 per cent silicic acid, which is melted by the oxy-hydrogen flame, and it is now possible to melt and to mold into almost any desired form as much as 50 pounds of quartz at a time.

One of the most remarkable properties of the quartz glass produced by this process is its resistance to acids. Even boiling acids, with the exception of hydrofluoric and phosphoric, will not readily affect it. Quartz has the advantage of having a very low coefficient of expansion, consequently silica ware may be made white hot and then plunged into cold water without being affected, being about 1/17 that of the best glass suited for chemical utensils and apparatus.

The methods of manufacture have of late been greatly improved on, but many of these improvements are maintained as trade secrets. So far the industry in this country practically use only the oxy-hydrogen flame for melting the quartz. One of the methods employed is to heat quartz for some time at a temperature of 570° C., which causes it to break up into small pieces, which are afterward fused in crucibles made of iridium or crucibles made of a mixture of zirconia and alumina. The latter being less expensive.

The fused silica is then worked like glass, and flasks of 60 cc. capacity can be blown without difficulty.

The material for casting is accomplished by the use of iridium molds, so as to obtain hollow cylinders which are afterward blown and worked in the oxy-hydrogen flame.

Fusd silica ware at 1,000° C. becomes pervious to gases, at 1,600° C. it softens. Devitrification is induced by prolonged heating at 1,200° C. Short exposure at higher temperatures does no harm. The density of clear fused silica ware is 2.22. For ultra-violet rays it is more transparent than any other glass. Fused silica ware is used in connection with the mercury vapor lamp and in the manufacture of chemical utensils and apparatus. The manufacture of quartz glass in the United States is only of very recent date.

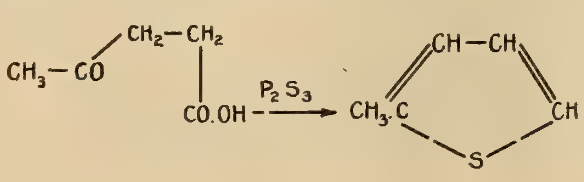
SYNTHETIC RUBBER

In the manufacture of synthetic rubber it is necessary to first manufacture either one of these three materials, butadiene, isoprene or dimethytbutadiene. These substances are certain unsaturated hydrocarbons which are allowed to polymerize and form a series of caoutchoucs which possess many of the properties of the best sorts of natural caoutchouc, including the power to vulcanizing.

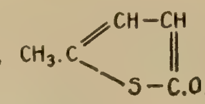
Several processes for the manufacture of isoprene are used, among them one that uses hydrogen. This process is:

Isoprene from starch or sugar through laevulinic acid. The process is highly technical as the reader will observe.

Starch or sugar is converted into laevulinic acid, $CH_3.CO.CH_2.CH_2.COOH$, by boiling with dilute HCl or H_2SO_4, and distilling the acid with phosphorous trisulphide at 130° to 140° C., whereby thiotolene distils over:

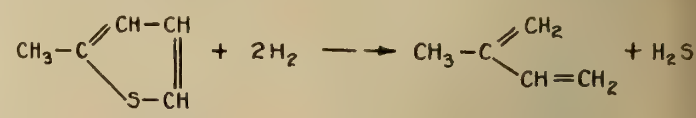


If phosphorous pentasulphide is used in place of the trisulphide, thiotenol,



is obtained.

The thiotolene or thiotenol is converted into isoprene by passing either compound mixed with hydrogen over finely-divided copper or iron at a temperature of 300° to 500° C. In the presence of hydrogen the sulphur is eliminated and combines with the metal forcing a metallic sulphide, which is then reduced by the excess of hydrogen to free metal. The final product is isoprene:



THIOTOLENE ISOPRENE

Above 500° C. the isoprene is converted into its polymer-dipentene, $C_{10}H_{16}$.

HYDROGEN IN BALLOONS AND DIRIGIBLE AIRSHIPS

Hydrogen, on account of its very low density, has the greatest lifting power of all gases, and is therefore used for filling balloons. The ascensional force of hydrogen depends on specific gravity, temperature, and the barometric pressure of the atmosphere. A liter of hydrogen gas under normal conditions has an ascensional force of 1.2 grams. The specific gravity of 98 per cent hydrogen is 0.087, which corresponds to a lifting power of 73.5 lbs. per 1,000 cu. ft. Pure hydrogen has a specific gravity of 0.06949, which corresponds to a lifting power of 75 lbs. per cu. ft.

Hydrogen for balloon purposes must be free from impurities that would injure the fabric, and should be dry. It is not necessary that the hydrogen be under pressure for inflating a balloon. It will readily inflate at atmospheric pressure.

Hydrogen for balloons according to history was for the first time used as an experiment August 27, 1783 by Professor Charles at the Champs de Mars, Paris. In December of the same year Professor Charles and his brother Robert, made a balloon ascension in which hydrogen was used.

The use of hydrogen for inflating toy balloons is in considerable demand. The following table of tests which has been recently worked out by actual tests on different size rubber balloons will be found useful in approximately determining the amount of hydrogen required to inflate the various sizes of toy balloons.

Table of Tests on Volumes of Hydrogen for Toy Balloons[2]

Size	No. 50	No. 60	No. 110
Size inflated	6″ to 6½″	7″ to 7½″	9″ to 10″
Hydrogen required for			
one cubic inch	140 to 170	220 to 250	440 to 550
Cubic foot	.081 to .1	.125 to .145	.25 to .32
Cu. ft. of hydrogen required for one gross	11.7 to 14.4	18 to 21	36 to 46
No. of balloons inflated per 100 cu. ft. of hydrogen units	1,234 to 1,000	800 to 690	400 to 312

Above figures are subject to variation due to: 1. Difference in temperature, 2. Differences in atmospheric pressure, 3. Differences in elasticity of rubber, 4. Differences in rate of charging.

CALCIUM LIGHT

Is used for the purpose of projecting pictures upon screens in illustrating lectures, illuminating and signal purposes.

[2]If charged too rapidly, gas blown into balloon will be cold and on being left standing will acquire a temperature of the surrounding air and increase in volume.


HAND-CUTTING MACHINE, OPERATING ON A 16-INCH BILLET

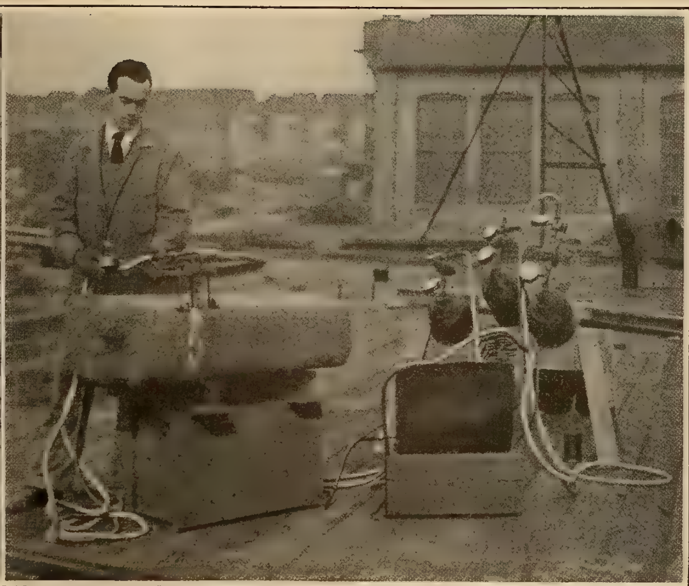


PLATE-CUTTING MACHINE, CUTTING A 24-INCH STEEL BILLET

Oxygen and hydrogen are burned through a special jet which prevents the gases from mixing before they reach the end of the tube where the combustion takes place. It is constructed on the principle of a blow-pipe and gives approximately 1,000 candlepower.

The hydrogen is first passed through and lighted; then the oxygen is passed through slowly, the pressure being regulated from the cylinders and increased until the flame appears thin and straight. This solid flame gives little light but is intensely hot. When the oxy-hydrogen flame is allowed to play upon some substance which it cannot melt or burn, the substance becomes heated to incandescence and gives off an intense light. The substance commonly used for this purpose is quicklime. Hence, the light is frequently called calcium light. It is also known as the Drummond light. Drummond having used it first in 1826.

The temperature of the oxy-hydrogen flame is about 2.537.78° C.

CUTTING BY THE OXY-HYDROGEN PROCESS

The process of rapidly cutting iron and steel with the blowpipe and a jet of oxygen has been considerably developed, and its application for rapid cutting by oxidation of the metal has only been known industrially for a comparatively few years. It is well known that metals made intensely hot burn easily and rapidly in an atmosphere of oxygen. Iron heated from 1,300 to 1,500 degrees F. has a wonderful affinity for oxygen and instantly combines with it to produce various forms of oxides. Therefore, if a jet of oxygen is directed upon iron that has been brought to a point of incandescence the oxygen oxidizes the metal at the point of contact. In other words, burns it. The design of an oxy-hydrogen blow-pipe especially intended for cutting iron and steel consists of a heating flame and a special ejector of oxygen under pressure. The operation consists of projecting, on the metal previously heated to redness, a jet of oxygen escaping under a sufficient high pressure. The oxide is driven away as it is produced, and the combustion extends throughout the thickness to be cut. Various gases are used as a preheating flame with oxygen in cutting of metals, viz., the commonly used acetylene which contains considerable carbon. Carbon unites with the molten metal and causes an excess of slag to form. Therefore owing to this tendency of carbon to form an excessive amount of slag, gases containing carbon retard the action of the flame, give rough cuts and prevent the action of the flame on the metal from penetrating to any great depth. Thus hydrogen being free from carbon and impurities give a speedy, deep and clean cut with oxygen which is not obtainable from all other gases used in conjunction with oxygen as a preheating flame.

Iron and steel over twenty-four inches may be cut with the oxy-hydrogen flame. For light cutting, the hand torch is used and for the cutting of plane surfaces up to twenty-four inches, the cutting machine is used.

Oxy-hydrogen flame lends itself more than any other process to the preparation of cutting of iron and steel.

REMOVAL OF METALLIC MASSES BY THE OXY-HYDROGEN FLAME

The speedy removal of metallic masses, such as slag or residue in blast or cupola furnaces, which seriously retards the proper working of the furnace, is often of the greatest importance, and to effect the removal of these masses by ordinary mechanical methods necessitates hours, and even days of very strenuous effort. Obstructed or "frozen" delivery holes are also of frequent occurrence, with a resultant loss of time while the furnace is out of operation, and often a total commercial loss of the charge.

For the removal of objectionable masses within the furnace, or the rapid opening of obstinate delivery holes, the oxy-hydrogen flame is admirably adapted when brought in contact with the combustible slag or other metallic masses at the proper temperature, produces intense heat with the immediate result of oxidation of the heated metal. Thus clogged or "frozen" tap holes in iron furnaces are easily and quickly opened, a hole eight inches in diameter being made at a rate varying from a half inch to an inch in a minute, depending on the depth of the hole. The oxy-hydrogen torch employed consists of a burner head, with four preheating nozzles, supplied with a mixture of pure oxygen and hydrogen and one nozzle located at a certain distance from, and in line with, the preheating nozzles, which are supplied with pure oxygen only. The operating end of the torch is at a sufficient distance from the burner head to insure perfect ease and safety to the operator even while cutting the deepest hole.

A flow of fresh water is maintained which effects a continuous cooling at the burner points, and keeps the entire torch cool. Ordinary city water pressure is ample for this purpose, and is admitted to the operating end of the torch by means of a single light hose. On the operating end of the torch, connections for the water and gas tubes are provided together with valves for the regulation of the water supply and gas for the preheating and oxidizing nozzles.

In the Fig. 5 diagram of the oxy-hydrogen perforating torch, tank *A* contains oxygen and tank *C* hydrogen, both under pressure. *D* and *F* are pressure regulators, which automatically maintain the desired pressure of the two gases at the nozzle *L*, where they are mixed in the proper proportion

MULTIPLE BURNER TORCH BURNING A 5-INCH HOLE THROUGH A 12 X 12-IN. STEEL BILLET 18 INCHES LONG

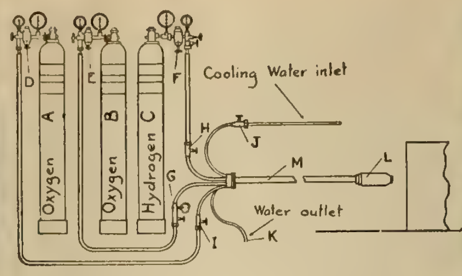


FIG. 5. DIAGRAM OF THE OXY-HYDROGEN PERFORATING TORCH SHOWING CONNECTIONS TO WATER COOLING SYSTEM

COMPLETION OF THE OPERATION SHOWING TORCH CLEAN THROUGH THE BILLET—WORK DONE IN 12 MINUTES

before ignition, at the one or more nozzles which constitute the preheating flames.

Tank *B* contains the oxygen supply, under pressure, for the single nozzle *L* and is conducted through the regulator *E*, rubber tubing and valve *G* to this nozzle and strikes the metal which has already been heated by the preheating flame, and burns or oxidizes it. *H* and *I* are shutoff valves, for the preheating gases, located on the apparatus. *M* is a pipe casing, *J* the cooling water inlet valve for regulating the water supply which circulates through the nozzle, and *K* is the discharge.

OXY-HYDROGEN AUTOGENOUS WELDING

Oxy-hydrogen autogenous welding introduced for industrial welding in 1901 is a process of obtaining joints by fusion of metal under the action of the oxy-hydrogen blow-pipe flame. It consists in uniting the metal which is in the liquid state, to operate in such a manner that its physical, mechanical, and chemical properties are not seriously modified at the place of welding, so that they approach as nearly as possible the properties of the original material. In welding thick pieces, say from 1/8 to 3/16 inch by any of the fusion methods, it is customary to bevel or chamfer the two edges of the joint and fill the "V" thus formed by melting metal from a rod by means of a torch. The technique of oxy-hydrogen autogenous welding does not require great effort to master but it is necessary to learn certain elementary principles and then exercise judgment as each application warrants. The oxy-hydrogen process for welding of thin sheets of iron or steel or special alloys is limited up to 1/8 inch thick, but for welding of brass, copper, lead, aluminum, it is particularly adaptable and is often preferable to oxy-acetylene. The reason for this is that with the high temperature of the oxy-acetylene flame, it is easier to burn these metals than with the oxy-hydrogen flame, the temperature of which is considerably lower—about 2,800 C., and that of the oxy-acetylene flame about 4,000 C.

COOKING UTENSILS, ALL PARTS OF WHICH ARE JOINED BY OXY-HYDROGEN WELDING

One cubic foot of hydrogen produces 88 calories or 350 B.t.u., and that of acetylene 410 calories or 1,630 B.t.u. The combination of the two gases may vary in the proportion of one volume of oxygen mixed with from four to six volumes of hydrogen, depending on the style of torch, the skill of the operator and character of the material to be welded.

The following is a table of gas consumption:

Table of Welding and Gas Consumption
(*Oxy-Hydric Bulletin*, p. 28)

Thickness of the Metal in inches	Nozzles welding	Gas Consumption in Cubic Feet for Lineal Foot of Metal Welding		Time for Welding of Metals 12 In. Long	
		Oxygen	Hydrogen	Min.	Secs.
1-32	No. 1	0:08	0:33	2	:00
1-16	No. 2	0:33	1:3	3	:00
1- 8*	No. 3	0:5	2:	3	:30
3-16	No. 4	0:6	3:	4	:00
1- 4	No. 5	0:8	4:	5	:00

*Oxy-hydrogen welding for steel plate over ⅛" is not to be recommended.

The gas consumption and time on material of a greater thickness than ¼ inch cannot be tabulated with any degree of accuracy, as much depends on the nature and class of the weld.

LEAD BURNING

The standard technique of lead burning is similar to that of oxy-hydrogen welding and can be defined as autogenous welding, as the parts are joined by melting the end of a strip of lead of the same composition as the lead plates to be united.

The gases used in lead burning are usually oxygen and hydrogen, both gases under a pressure of from one to two pounds per square inch, in a torch designed to mix the gases in the correct proportion. The oxy-hydrogen flame is applied directly on the strip of lead and is also allowed to play at the same time against the edges of the work until the surface of the lead plates are softened almost to the point of running and the strip of lead is melted in small portions so that a drop at a time of the lead will fall into the joint, thereby making a union in the plates. Considerable judgment and experience are required by the welder to obtain results, as it is necessary to remove the flame constantly from the work. The flame must have a very fine point to obtain satisfactory results.

Hydrogen and air or oxygen, also oxygen with acetylene, or illuminating gas are used in a limited way for lead burning. It is claimed by those who have used air, acetylene or illuminating gas with oxygen, that the combination of oxygen and hydrogen is superior.

OXY-HYDROGEN PLATINUM MELTING

In the melting and welding of platinum the oxy-hydrogen burner is used almost exclusively. The great advantage of this flame is that it contains no elements injurious to the platinum such as carbon. Illuminating gas was formerly used instead of hydrogen. The operation is carried out by

passing oxygen and hydrogen at high pressure through an especially constructed oxy-hydrogen torch. The author devised a torch for this work several years ago, and it is practically the only platinum melting torch (oxy-hydrogen) used to today in the United States by platinum smelters. The melting is best accomplished in a lime crucible. Oxygen and hydrogen at a pressure of 1,800 pounds per square inch in cylinders containing respectively 100 and 250 cubic feet with reducing valves and regulators are used. (See Fig. 3.)

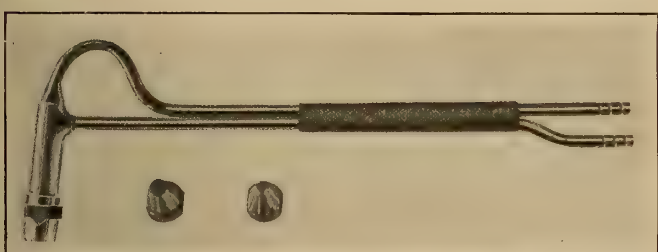
On account of the tendency of platinum to absorb hydrogen and consequent bubbling of the surface, it is necessary to keep a slight excess of oxygen in the flame. Unless care is exercised to have the component gases (oxygen and hydrogen) present in approximately the necessary amounts for perfect combustion the platinum becomes more or less brittle, depending upon the amount of hydrogen retained.

PRE-TREATMENT OF STEEL IN NICKEL PLATING

One of the chief difficulties encountered in nickel plating of steel which has a tendency to scale or peel off has been overcome by the use of hydrogen.

The process is carried out approximately on the following lines (see Fig. 6), the process being continuous:

The sheet steel in a roll is passed first through a chamber of hot hydrogen, which reduces all oxides and gives it a fresh surface. From this chamber it is passed into a second chamber which is a cooling chamber containing hydrogen; it is then placed in the nickel bath and through the wash tank; then again through a third chamber where it is raised to welding heat; and finally to a cooling chamber. The speed is gaged to allow each step of the operation sufficient time.



OXY-HYDROGEN TORCH WITH TIPS FOR MELTING VARIOUS QUANTITIES OF METAL

The working out of this problem has been of great importance to the manufacturer who is welding nickel-iron sheets.

MANUFACTURE OF TUNGSTEN AND MOLYBDENUM

Tungsten and molybdenum in the early stages of their history were produced from their oxides by reduction with alkaline metals. Woehler, as a rule, has been given the credit of having first produced metallic tungsten, but a close study of the literature divulges the fact that metallic tungsten was known and has been produced by this same method as early as 1790.

During the latter part of the nineteenth century, tungsten and molybdenum were produced by reduction from their oxides with zinc and carbon, and tungsten for technical purposes is even now chiefly produced by the carbon reduction method.

Wherever tungsten and molybdenum of high purity are required, both metals are now produced by reduction with hydrogen.

Tungsten in particular has grown during the last decade in importance and the modern illuminating problem can be said to have been solved only by the aid of tungsten. A tungsten filament lamp, that is the incandescent lamp having an illuminating body or filament which consists of pure metallic tungsten, has not only completely displaced the old carbon filament lamp, but has also popularized the electric light as against the gas light and is slowly but surely displacing the arc light from the street.

This success of the tungsten incandescent lamp is in turn due to some extent to the development of the production of pure hydrogen on a large scale and at a comparatively low price. While it is possible to obtain pure tungsten by other methods, the reduction by hydrogen undoubtedly is the most convenient one and from the point of view of purity of the product is the most important one. Both zinc and carbon, if used in excess, remain in the tungsten as impurities, whereas, an excess of hydrogen is not in any way harmful to the tungsten on account of its gaseous nature.

For the production of tungsten and molybdenum the trioxides of the metals WO_3 (tungstic acid) and MoO_3 (molybdic

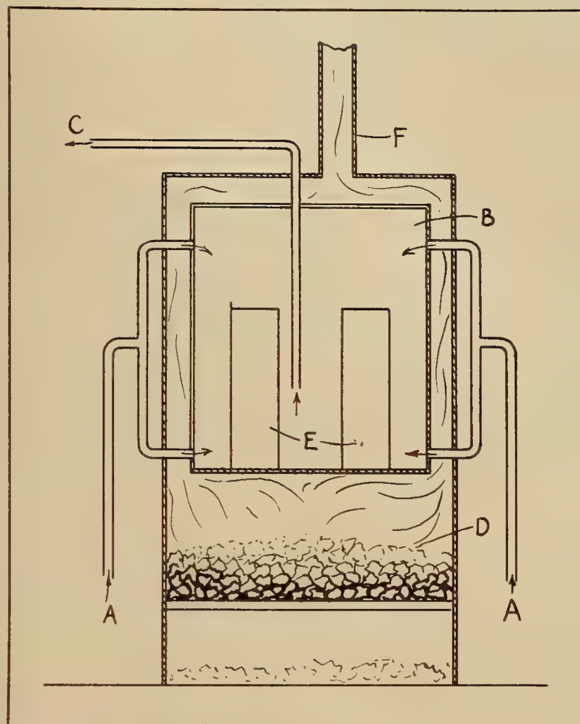


FIG. 6. ANNEALING FURNACE FOR SHEET STEEL TREATMENT BEFORE NICKEL PLATING

AA, source of hydrogen supply; *B*, chamber for heating steel in hydrogen; *C*, spent hydrogen outlet; *D*, fuel chamber; *E*, rolls of sheet steel; *F*, flue.

acid) are employed. Both are obtained from their ores wollframite, scheelite, hubernite or ferberite (in the case of tungsten) and molybdenite or wulfenite (in the case of molybdenum), by well known methods. The oxides as a rule are placed in boats and these boats are passed through tube furnaces which are heated externally either by electricity, gas burners, or in some other convenient manner, the tube temperature varying from 500° to 900° C. The exact tem-

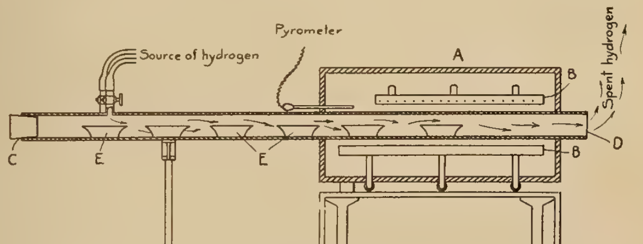


FIG. 7. FURNACE FOR REDUCTION OF TUNGSTEN AND MOLYBDENUM

A, furnace (insulated); *B*, heating burners; *C*, openings for inserting boats; *D*, opening for removing boats; *E*, boats

peratures are different for the two metals and are of importance if the final structure of the resulting metal powder is to be considered, but principally and for the present purpose they are negligible. Through the tube there is passed during the entire heating period, a stream of dry hydrogen. The hydrogen combines with the oxygen of the oxides and forms

water which is carried away by the flowing hydrogen in the shape of steam, leaving behind in the boats metallic powder of tungsten or molybdenum. A photograph of such an apparatus is reproduced at the head of page 341 and a diagrammatic sectional view is shown in Fig. 7.

The metals in powder form serve for only very few purposes. Molybdenum, and particularly tungsten, is used as a rule in the form of solid bodies, particularly as wires in electric incandescent lamps, where tungsten forms, as mentioned, the lighting body or filament, whereas, the supporting holders or hooks are in most cases formed of molybdenum wires.

Tungsten has found a great many other applications during the past decade. It has replaced platinum as a make and break contact in ignition systems and most automobiles are now equipped with tungsten contacts. Other important uses of tungsten are X-ray tubes, wireless outfits, dental purposes, and many other uses of vital importance.

Hydrogen is being used during almost the entire process of transforming metallic tungsten powder into the various shapes in which it is finally used. The metal is heated repeatedly for the purpose of facilitating the various operations carried on with it and if these heating operations were to be done in the open air, the metal would oxidize. It is, therefore, necessary to protect it by surrounding it with an inert atmosphere. As such, hydrogen is the logical one, it having been used in the production of the metal. Furthermore, hydrogen was recommended by the art for the same and similar purposes a considerable time ago, as for instance by Vaugeois in the French patent 168106 in 1885.

During the various processes which tungsten undergoes before being formed finally in the desired shape, hydrogen is applied in a number of machines and apparatus which are used. The principle is to surround the metal during the operation with a protecting atmosphere of the hydrogen and for this purpose bells or containers have to be constructed into which or through which hydrogen is passed.

The hydrogen which is used for these purposes is either taken from steel containers of the usual form, or in most instances produced in the manufacturing plants.

NEWEST USES OF HYDROGEN

The following references to new uses of hydrogen may be of value:

Liquid hydrogen for fuel in engines. Rome, May 7, 1920. *New York Tribune*. Italy.

Synthetic benzine. Compressed Gas Mfg. Association *Bulletin*, Dec. 23, 1920. Germany.

Turpentine and varnish substitute. *Rev. Chim. Ind.* 29, 173-8 (1920), *Chemical Absts.*, Vol. 14.23, p. 3,803. France.

SYNTHETIC PRODUCTION OF PETROLEUM

For many years we have been the great petroleum producer. The world could not have progressed as it has during the last fifty years had it not been supplied with American petroleum. At home these oils have enabled us to develop agriculturally, industrially and in many other ways in a marvelous manner. Let us now awaken to the fact that unless something revolutionary occurs, all this will be changed. Sir E. Mackay Edgar, an English authority, recently made this statement: "In ten years' time America will be forced to buy annually from Great Britain 500 million barrels of oil." This is a most startling prediction, and, if it be fulfilled, might spell disaster to many of our interests—hence we must examine the facts and see if it is likely to occur. In my own efforts to do this, I have gone over the figures showing the petroleum marketed during the last forty years and have found, in round numbers, as follows: In 1898 it was 55 million and in 1918 it was 350 million barrels. From these statistics we learn the consumption during the twenty years from 1878 to 1898 increased 266 per cent, and that during the next twenty years the increase was 536 per cent, and if we assume the increase during the last twenty years, it will have increased 268 per cent over the figures for 1918 by the year 1928, which would make the consumption no less than 938 million barrels. It may be said this amount will not be required in the United States as foreign countries will be producing their own oils; but it is quite certain the increased use of petroleum as a substitute for coal in producing power for vessels and manufacturing plants will more than make up for the lost foreign trade.

It would seem that Sir E. M. Edgar's prediction would come true unless we do some things we are not now doing. There are possible ways of avoiding this calamity. The immense oil shale deposits in our Western States form a source of supply of petroleum, but, unfortunately, there are great difficulties to overcome in their utilization. A ton of shale would yield approximately one barrel of oil, hence 938 million barrels of oil per year would require the working up of 938 million tons of shale each year, and this is well-nigh twice the amount of coal mined in the United States in one year. All this shale would have to be retorted to distill off the oil, and it is difficult to believe this possible, and certainly it is not possible within the ten years, and probably not in twenty. We have not the man power to do it with, and in the meantime we are rapidly approaching the exhaustion of our natural petroleum.

Certainly this whole situation has a serious aspect, but I think we can find a favorable solution. Petroleum is a compound of carbon and hydrogen in about the proportions of eighty parts carbon to twenty parts hydrogen. The carbon and hydrogen in this shale as mined from the earth have not yet united to make petroleum, but the simple act of heating the shale causes them to unite and form petroleum which can be distilled off.

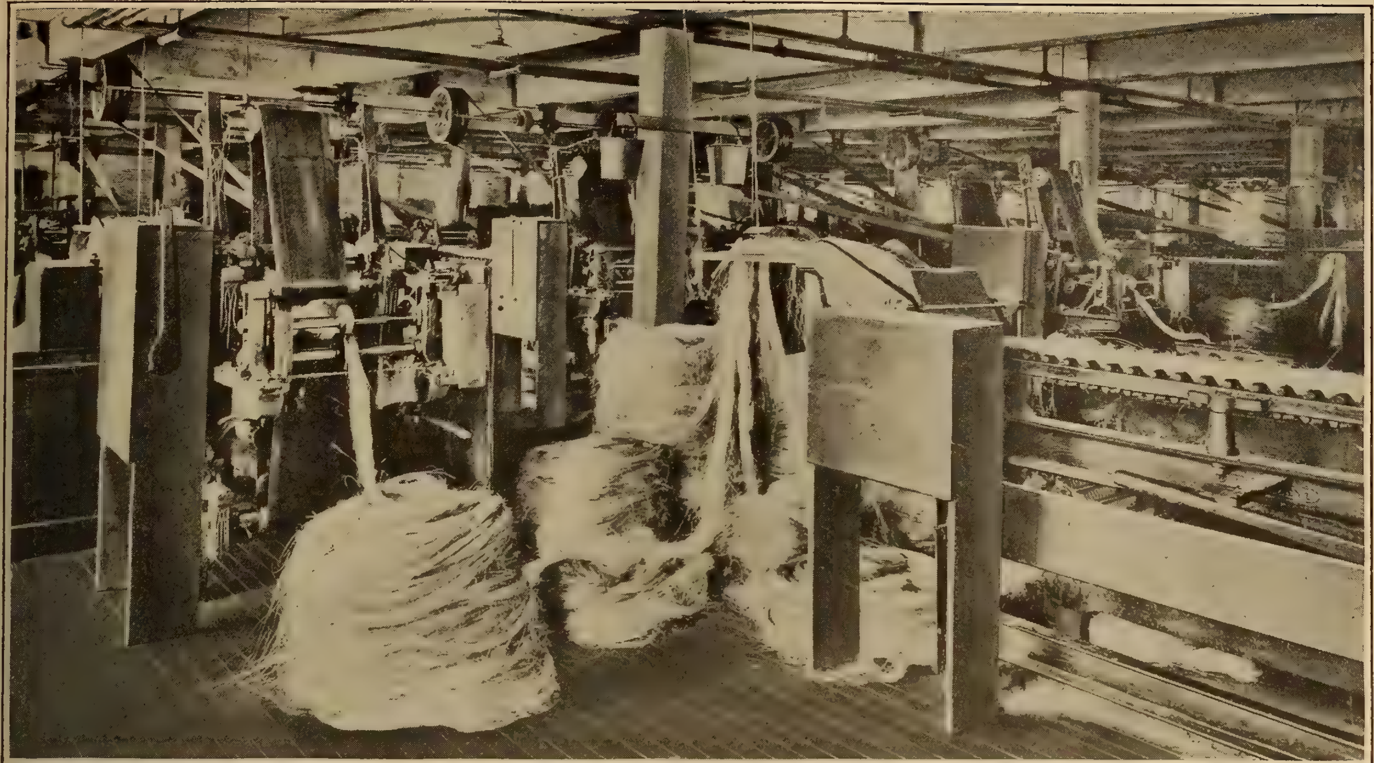
It would be belittling man's mental power to assume he cannot learn how the carbon and hydrogen are associated in the shale rock and be able artificially to produce this combination in such quantities as he desires. Carbon and hydrogen are elementary substances to be had, the carbon from our coal, even of the lowest grade, and the hydrogen from water, and we may consider them inexhaustible. This problem can, and undoubtedly will be solved by some one of our 15,000 or more chemists, but it is, in fact, a national problem, and could come under Government supervision. It would well justify the offering and payment of a handsome reward for its early solution.—Abstract of a paper by Dr. Edward G. Acheson, read before the Waterpower League of America.

COOLING OF LARGE ELECTRICAL MACHINES

Electrical machines of high specific power, such as turbo-alternators, have hitherto been generally cooled by simple air circulation.

This system has several disadvantages, the chief of which are the difficulty in eliminating dust, and the risk of spreading fire present when large volumes of oxygen are being driven through the windings. Other systems have been recently proposed, such as the addition of surface or water-jet cooling radiators for the circulating air (*General Electrical Review*, Feb., 1920), and direct water cooling by water led through pipes and cavities in the machine frame. These proposals are criticised by the present author—the first as exceedingly cumbrous and as not removing the risk of fire, while adding (in its alternative form) the risk of humidity, the second as still necessitating air for the cooling of the rotor and the bulk of the stator.

The author, in collaboration with M. Corblin, has been working for a long time past on a new system which he has just patented, in which the cooling is effected by a suitable volatile liquid led to the parts to be cooled, where it is vaporized, then condensed and used again. This process permits, at least theoretically, the collection of the heat produced in an electrical machine, part in the form of motive power and part in the form of useful heat. Among the liquids suggested and discussed are carbonic anhydride, sulphuric anhydride, and methyl chloride.—P. Bunet, *Revue Générale de l'Electricité*, Sept. 4, 1920. Abstracted by *The Technical Review*.



THE FASHIONING OF MANILA HEMP INTO "SLIVERS" PREPARATORY TO SPINNING THEM INTO STRANDS

Manufacture of Rope and Twine

Treatment of Manilla Hemp, Sisal and Jute in a Modern Rope Factory

By S. G. Williams

Photographs Copyrighted by Publishers Photo Service

In our last issue Mr. S. G. Williams described the primitive methods employed in obtaining hemp from the wild banana plant. The article is here supplemented with the story of what is done with this hemp, as well as other rope fibers, after reaching a modern rope factory.—THE EDITOR.

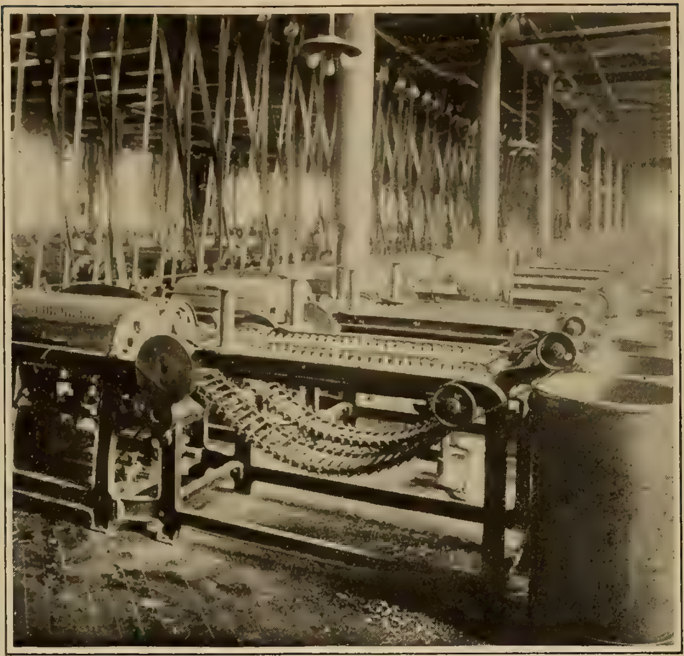
BEFORE touching upon the mechanical side of this subject, let us discuss sisal and jute which, after reaching the factory, are subjected to the same processes as those employed in the production of cordage from hemp. It is from Yucatan, Mexico, that we get most of our sisal fiber, where climatic circumstances and an ideal soil combine to yield annually anywhere from 750 to 900 pounds of fiber per acre. The heniquen plant, from which sisal is got, is one of the cactus family, and from the trunk of the growth project an array of sword-like leaves containing the desired fibers. A vigorous heniquen will continue to produce good leaves for a decade; and its yearly crop will range between 20 and 30 leaves. The plants are all grown from sprouts set in rows from 8 to 10 feet apart, and reach a cutting stage in about five years. Care must be taken to see that the heniquen is not permitted to flower, because the blossoms reduce the sap in the leaves and cause them either to wither or to yield a fiber of a much reduced strength. Similarly, the plants after they are ten years old lose their vigor, and the sisal filaments reflect this decadence.

PREPARING THE FIBER FOR SPINNING

In harvesting sisal, the natives cut off the leaves, one by one, with a large and heavy knife, and a day's work for a field hand varies from 2,000 to 3,000 leaves. After the spiny leaves have been chopped off from the parent plant, they are tied in bundles ready for transporting to the decorticating machines, which strip off the pulpy material preparatory to washing the fiber. The filaments are next washed and then hung up to dry in the sun. When thoroughly dried and bleached, the heniquen hemp, as it is sometimes called, is baled by a press, covered with cloth and made ready for shipping. Sisal fiber is not equal to Manila hemp in flexibility, and the filaments are shorter and have a tendency to splinter. A good grade of sisal is something like 75 per cent as strong as a corresponding grade of Manila

hemp, and for this reason it is not used in ropes where much strain is likely to be encountered or where wearing quality of a high order is expected. Sisal rope finds its greatest service in agricultural activities and wherever the requirements are not over exacting.

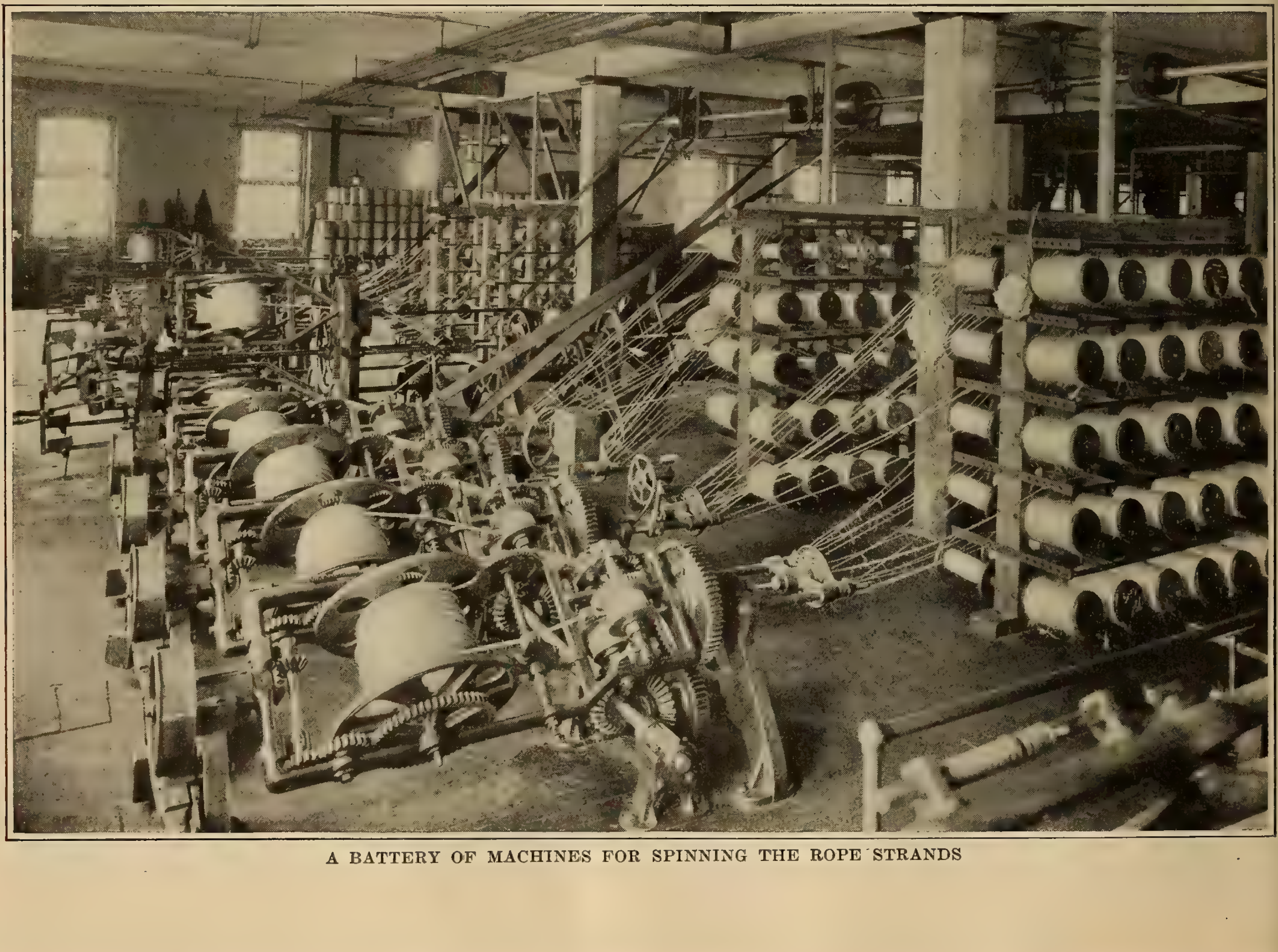
But for the farmer's need of a binding twine, suited to the operation of the mechanical harvester, we might still know little if anything about the virtues of heniquen. So recently as forty years ago, one large rope works in Pennsylvania brought out and marketed a binder twine fashioned entirely from sisal, and in doing this followed immediately in the footsteps of William Deering. The year before, Deering had put his harvester to a test in the Western wheat fields, and his principal difficulty was the lack of a twine of marked and uniform strength. It wasn't until he made twine of sisal, experimentally, that he hit upon the thing needful to the satisfactory working of his ingenious labor-saving apparatus. He blazed the way for a domestic industry which now produces fully $25,000,000 worth of binder twine each twelve months. The world over, a matter of 600,000,000 pounds of twine and rope of the lower grades are called for in dealing with the annual harvest of cereals.



MACHINES FOR COMBING AND STRAIGHTENING THE FIBER THREADS

Yucatan produces normally a million bales of heniquen; and most of the crop is bought by us and worked up by our cordage factories.

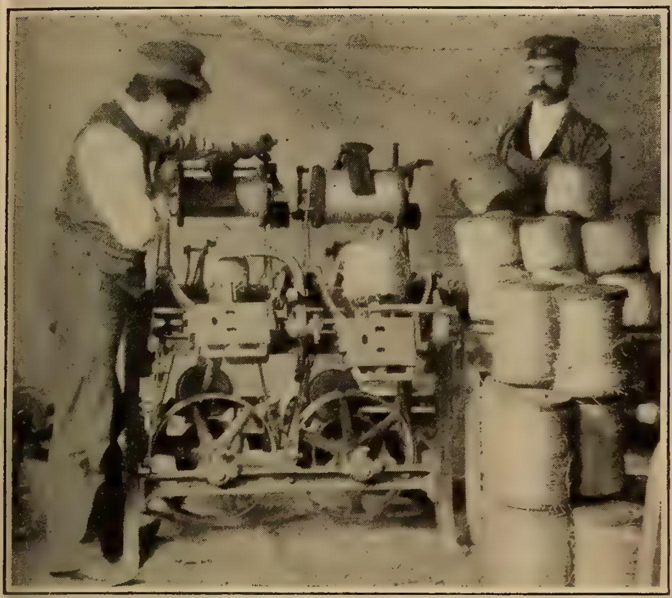
Jute figures conspicuously in the manufacture of a great variety of twines and rope for special purposes, such as for clothes lines, halters, tent ropes, bed cords, etc. The fiber comes from a plant grown in the main in a certain section of India, and the filaments are separated from the enveloping vegetable substance by retting. The stalks are from 10 to 15 feet long, and are immersed in water for a period of about ten days. The resulting fermentation makes it easy to strip the fibers after the removal of the slimy mass from the retting pool. When the filaments are cleaned, dried, and duly graded, they are made into hanks, baled, and then shipped abroad. The objectionable feature about jute, apart from its inferior strength when compared with hemp or sisal, is its tendency to absorb moisture from the surrounding atmosphere, which causes it to expand and contract according to the state of the air. In passing, it may be said that the growing of jute of a superior character is entirely practicable in some of the southern parts of the United States; and there is reason to believe that its cultivation may be brought to a



A BATTERY OF MACHINES FOR SPINNING THE ROPE STRANDS

point here which will make us well-nigh independent of foreign sources of supply. And now for the manufacturing processes by which hemp, sisal, and jute are worked into cordage; and for the sake of simplifying the story let us deal alone with the handling of the prime raw material, hemp.

After bales of Manila hemp have been duly sorted at the factory, the fiber goes into the preparation rooms of the establishment, where it is cleaned and combed by an array of machines variously known as breakers, spreaders, draw frames, and finishers. These apparatus are fundamentally alike in principle and differ only in operative details which serve progressively to comb out and to straighten the fibers and to give them, the while, a characteristic soft and silky appearance. The machines have movable belts composed of bars studded with steel pins—the pins becoming more numerous and smaller as the combing stage progresses. In its final state, the hemp flows from the funnels of the apparatus in a stream of loosely associated filaments, known to the trade as "sliver," and this is deposited into tall metal cans.



WINDING TWINE INTO BALLS

The next step takes the slivers to the shipping room, where the tresses of hemp are further subjected to combing and straightening, and are then twisted into "yarn." Simple as this sounds, much care must be exercised to see that the spindles turn out yarn of uniform size. The yarn is taken from the spindles and wound mechanically upon large bobbins or spools. Yarns for various sizes and kinds of ropes differ, of course, as to thickness and grade as well as in the number of fibers worked into them. The operatives in charge of these machines in the spinning room are highly skilled, and upon the thoroughness of their supervision depends in no small degree the fitness of the ultimate cordage. In short, the final rope is strong or weak according to the sturdiness of its basic unit, the yarn.

With the yarns available, the rope maker then chooses just the right number of them to form a "strand" of a given size. In the parlance of the cordage manufacturer, and likewise in the language of knowing rope users, the strand is the classifying element, and the number and getup of these in a rope is fixed in accordance with the service for which the line is designed. The several yarns—fed from their respective bobbins—are led through a draw frame, which guides the yarns while they are being twisted into strands. The cunning workman sees that his strand is subjected to the right tension and that it has just twist enough to insure the specified strength and elasticity. For general purposes, ropes are made of three strands, but when greater strength is needed, four strands are employed, and these may envelop a central core or heart. To meet particular requirements, ropes are fashioned of six and nine strands—the latter really being three three-strand ropes twisted into a single cable. In a nine-strand cable or hawser, the three ropes are laid into one by being twisted in a direction opposite to that in which the unit strands of the separate ropes are twisted. This makes for greater elasticity and produces increased wearing surface. A rope may be "hard" or "soft" laid, and this is determined by the amount of twisting, which naturally stiffens the line.

When a rope of a prescribed size and length is finished it is then wound into coils by machine. Towing hawsers, 15 and 16 inches in circumference, are made ready in this way for shipment, and each of these coils will contain 1,200 or 1,500 feet. Coils of lesser lines will hold from 2,000 to 3,000 feet of rope. These coils are strapped or bound by smaller cordage, and, for their better protection during storage and transportation, they are covered with bagging and stamped with the necessary descriptive text and the name of the manufacturer. In the composition of a drilling cable, 2¼ inches in diameter and 3,000 feet long, as many as 25 bales of Manila hemp are used. Cables of this kind are employed extensively in the search for petroleum in our oil fields, and in this realm of industry the ropes are obliged to withstand sudden and severe stresses.

Rope is laid or twisted by two methods: one wherein all of the operations are performed by machinery and the other by a combination of manual work and mechanical facilities. The latter is a development of the oldest procedure, and is still called "walk-laid." In former days, walk-laid rope was entirely a hand product, and the craftsman first built up his yarns from the fiber, next formed them into strands, and finally twisted them into rope while afoot and in motion—walking backward as he added inch by inch to the cordage. Nowadays, the rope-walk really relies upon various apparatus that travel upon tracks from end to end of long buildings extending far enough to permit of the fabrication of single cables, etc., measuring 1,500 feet. It is probably true that human supervision is more intimate and wider during the production of walk-laid rope than in the case of machine-laid rope, but the makers of the latter call to their aid highly trained workmen who are able to see to it that the machines function to a nicety in developing the tension suited to the twisting of the several strands. What this tension means has been made clear by one of our greatest cordage concerns. As explained by this enterprise: "Unless absolutely equal tension is put on all the strands, the rope will never have the tensile strength that it should, for, if one strand is run in slack or given

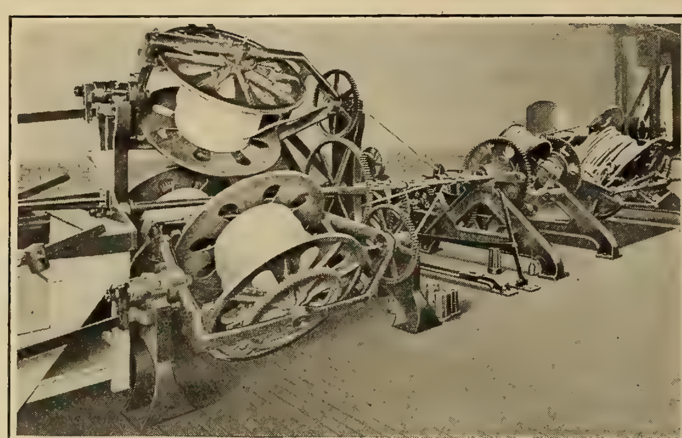
THE FIRST STEP IN MAKING A ROPE

Four strands of yarn are run into one machine which twists them into a single rope

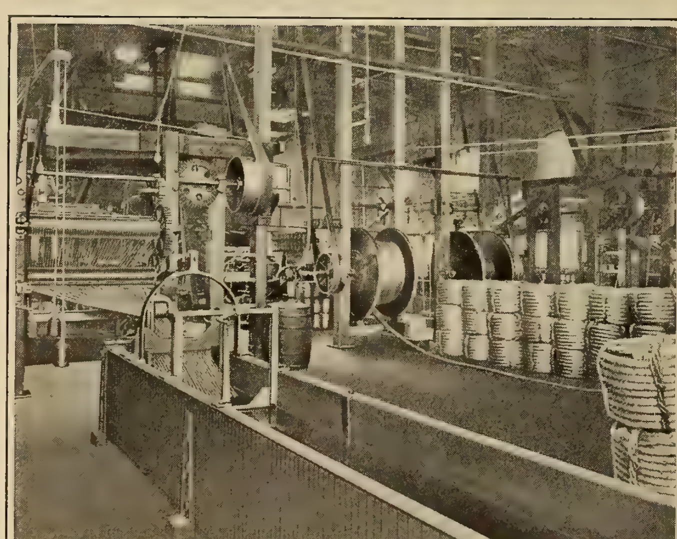
A ROPE WALK WHERE VERY HEAVY ROPE IS MADE

an excess amount of tension and held back, when strain is put upon the rope, it will either not bear its proportion of the strain or will take all the strain. In either case, the rope will not last so long as one in which all the strands bear the strain proportionately. That is why exact tension is one of the most important factors in the making of a rope."

In order that certain kinds of cordage may meet successfully the varying conditions of service, it is necessary to lubricate its constituent members during manufacture. A moment's thought will make the reason for this apparent. Plainly, the wear and tear upon a rope takes place both within and without. The internal wear is set up by the bending of the fibers and their frictional contact with one another, and this action is augmented when the rope becomes dry and fuzzy through use. To neutralize this, lubrication is resorted to; and a line properly lubricated in the making will outlast several dry ones. Although Manila fiber is by nature tough and strong, it becomes rough and harsh when dry. A suitable dressing, however, will render the filaments silky and smooth and thus greatly lessen friction. In passing it should be said that Manila hemp is the fiber par excellence for marine purposes because it will withstand alternate drying and wetting and is not harmed by exposure to salt water. In this respect it is radically different from sisal, its nearest competitor. No wonder, then, that there is an undiminished demand for Manila hemp; and the annual production of something like 100,000 tons in the Philippines is readily disposed of by the growers. To render sisal more nearly comparable with hemp in the manufacture of some small ropes, cords, binder twines, etc., it is the practice to waterproof the yarns by running them through a bath of heated tar.



THREE ROPES BEING TWISTED INTO A SINGLE HEAVY HAWSER



WATERPROOFING ROPE STRANDS IN A TAR BATH

In the trade, the sizes of fiber ropes are designated by their circumference, which is roughly three times that of their diameter, while wire ropes or cables have their sizes fixed by their diameters. The reason for this is to prevent confusion when ordering or referring to ropes without mentioning whether they be of fiber or metal composition. For the sake of those curious about the strength of cordage, the following brief table shows what was produced by one of our large manufacturers in meeting the specifications of the United States Government. Something like 1,500,000 pounds of lines were purchased in connection with a great national engineering undertaking, and the tests prescribed were of a very exacting character.

Circumference Inches	Strands	Required breaking strain, Pounds	Actual breaking strain, Pounds
¾	3	1200	1316
1⅛	3	1900	2100
1½	3	2500	4150
2	3	4000	5400
2¼	3	5000	6750
3	3	7800	10400
3½	4	10500	13200
3¾	4	12200	16100
4½	4	17400	21300
5½	4	27700	30000
6	4	31000	35600
7½	4	42300	45000
9	4	60000	77200

It would take a long list to enumerate the many ways in which fiber ropes figure in our daily and industrial life.

THE "EXPRESS" TYPE OF CONTAINER CAR WITH NINE FIRE- BURGLAR- AND WEATHER-PROOF STEEL CONTAINERS

Carloads of Safes

Using Portable Steel Compartments for Transporting Freight by Truck and Rail

"CONTAINER cars"—newly-invented types of rolling stock unlike any hitherto known on American railroads —which provide for radically changed methods of handling less-than-car-load lots of freight, have just been placed in regular service by the New York Central Railroad on its main line between New York and Chicago, with conspicuous satisfaction to shippers. The success attained by these cars in quick, safe, economical handling of valuable "l c l" freight and express on their first score of round trips, indicates the early extension of the system which means a revolution in the methods of handling such package freight throughout the country.

The container cars provide for the complete coordination in service of the three factors in transportation—the steam railroad, the motor truck and the electric railway. They are specially-designed cars carrying portable steel compartments of differing uniform sizes which are so devised as to be transported between the shipper's door and the railroad freight station and kept securely locked in transit. This in effect extends the rail head right up to the door of the consignor and consignee.

The prime purpose of the new container car system is greater security for shipments against loss and damage by theft and by wear and tear, great economies in time and labor expense, as well as reduction in loss and damage, by the elimination of many processes of rehandling from store or factory to truck, thence to freight platforms or warehouses and thence to the freight cars which are easy prey for burglars.

Losses of freight by theft and damage have grown so tremendously in recent years as to present a formidable problem to the railroad managements, and the organization of large and expensive police systems, as well as special educational campaigns among railroad employees and shippers to secure greater safety, better packing and more careful handling, seemingly have been ineffective in checking the steady advance of this wastage. The extent of this item of economic waste can be realized when it is known that for the year 1914 the American railroads paid out $33,000,000 to liquidate claims of loss and damage of freight, and this sum had grown to $125,000,000 for the year 1920. The cost to general business of such losses is not entirely covered, however, in the mere total dollars paid directly by the railroads in claims, and merchants and manufacturers, both buyers and sellers of all classes, are affected by the tremendous leak.

The new system is designed to make goods transportation as safe as is humanly possible for the entire journey from consignor to consignee, by providing an almost impregnable container—an individual private section of a car, for the entire journey between the place of business of the shipper and receiver of freight. This provides the "store door delivery" so long aspired to as ideal railroad service, but which up to now has never been brought to the point of actuality.

The container cars just placed in regular service are of different types, adapted to various commodities and speed schedules, the "express" type being built for handling in passenger trains and the "freight" type of standard construction for use in freight trains.

The "containers" or portable sections are like huge steel safes or boxes that at point of loading or destination may be lifted by means of cranes between the railroad car and motor trucks or electric cars. These containers not only have upon their doors strong locks that may be secured by the key of the shipper himself after loading, but when placed aboard the specially designed car the compartments fit down behind a strong steel bulkhead or fence which prevents the opening of their doors without the hoisting of the whole compartment. A very large incidental economy is expected to be realized through elimination of the necessity of boxing and crating of shipments, the cost of such packing cases being itself a formidable item. A container deposited at the shipping room of a consignor may be loaded direct from the shelves with goods in cardboard or other fragile packages with assurance that they will not be crushed nor touched until the consignee unlocks the steel compartment at his own door and removes the goods.

Several processes of billing and checking, engaging the services of numerous employees, obviously are eliminated by the container system. At present shipments of varying sizes must be checked out and receipted for in the first instance from shipping room to truck, from truckman to the receiving clerk at the railroad freight depot and again from the freight platform via hand trucks into the box car. All this is done away with by the new method, each shipper having an individual section of the car under separate lock, so that chance for loss, theft or damage is reduced to a minimum.

Still another economy to railroad transportation, and perhaps the greatest one, is the additional service that may be secured from rolling stock and terminal space. In busy times, when demands for transportation exceed the capacity of equip-

ment and terminal facilities, the problem is to keep the wheels of every freight unit turning and traffic flowing without interruptions which bring congestion and stalled tonnage. The time of detention of freight cars at terminal points for loading and unloading is a big factor, and labor shortages, the inaction of shippers and limited track and platform space have in the past combined to produce congestion that restricted the carrying capacity of the railroads when the utmost of service was needed. With ample supplies of containers on hand at terminal points for use of shippers at their places of business, these containers affording the utmost of protection to goods, there will be no need for cars to stand idle in overcrowded terminal yards and the time of loading and unloading will be reduced to a minimum. The clearing of a container car by the hoisting of the containers to and from trucks can be accomplished in a fraction of the time necessary to load and unload a box car by means of hand trucks. The container car, furthermore, need not be placed at a platform, but may be loaded or ununloaded by means of cranes at any point accessible to either motor trucks, drays or flat cars of electric railways.

With the growth of large cities, terminal track capacity has become more and more a factor in governing the extent of railroad service, and congestion at these points during recent years of intensive transportation activity seriously slowed up the flow of traffic and kept waiting tonnage that otherwise might have moved freely. At some points expansion of terminal facilities has practically reached its limit because of the encroachment of city developments and this has made imperatively necessary the devising of some means for keeping the mass of rolling stock moving almost continuously, if the essential loads are to be transported.

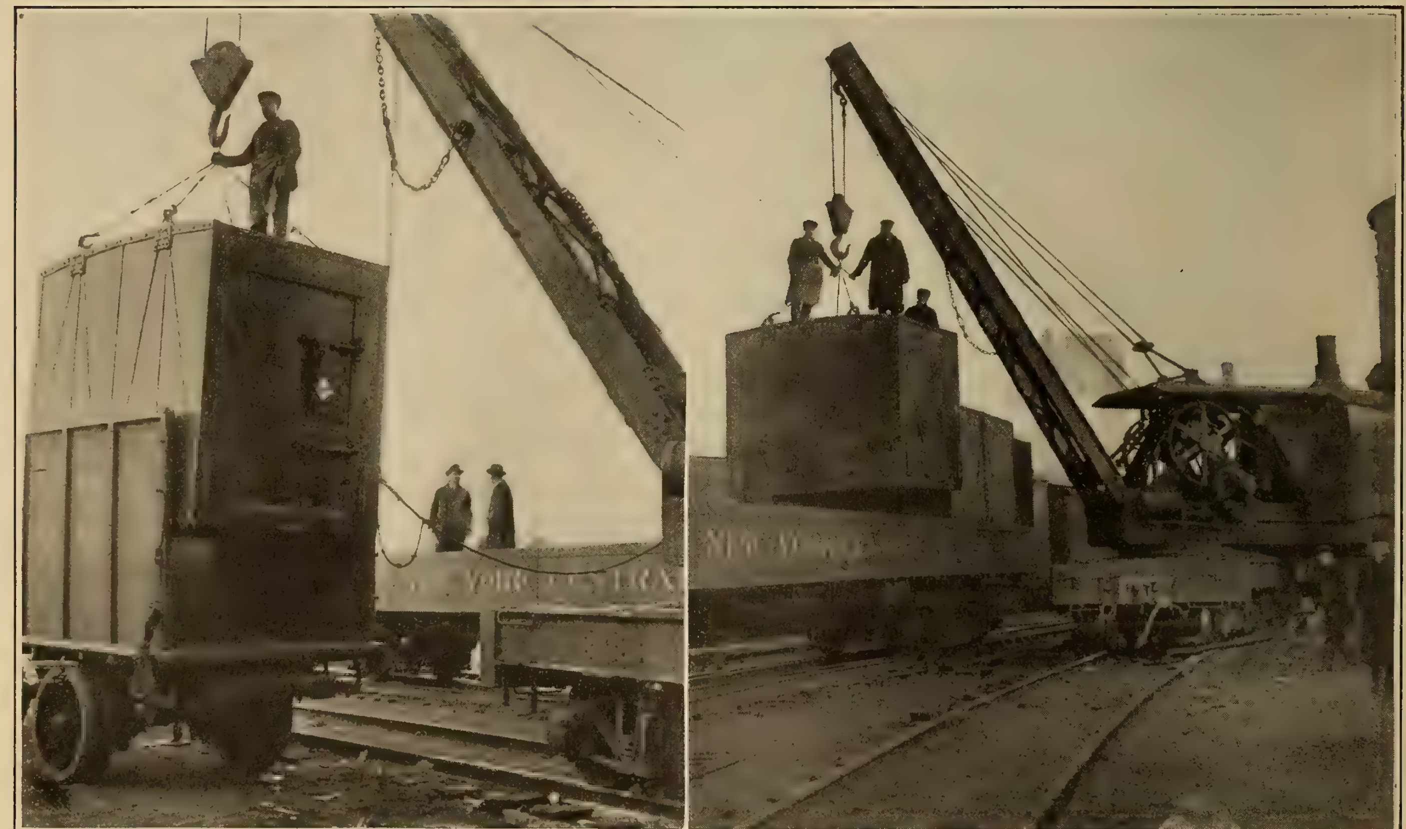
In recent operations of the "express" type container car between New York and Chicago the containers were removed from car to motor truck in from thirty seconds to ninety seconds each, although the most adaptable special crane equipment is not yet in the service, and plans for zoning which will assure the utmost expedition are not yet in effect. This cleared the car of load in a maximum of fifteen minutes.

The "express" type car is 63 feet in length, carries nine containers of uniform size, and has trucks, underframe and fittings that make it interchangeable with standard passenger equipment for use in any passenger train. Each of the nine containers is 9 feet wide by 6 feet long, with an inside clear height of 7 feet 4 inches and a door 3 by 6 feet. The steel containers are fireproof, burglarproof and water tight, with a carrying capacity up to three tons each. They have wooden floors and special attachments and reinforcements for convenient lifting and handling.

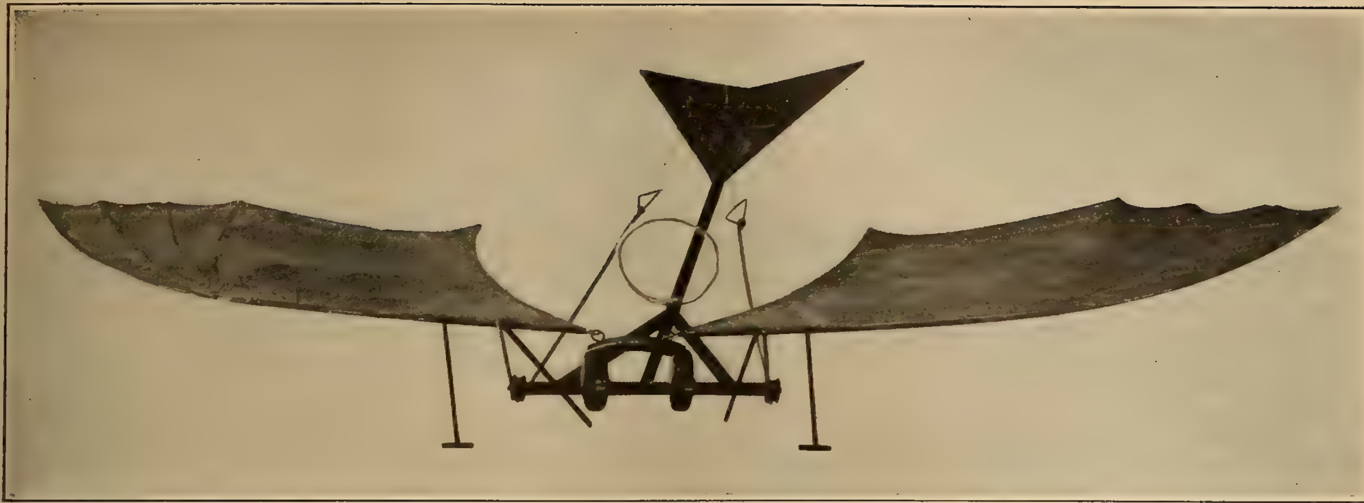
The "freight" type car is provided with containers of two sizes—15 feet and 7½ feet in length—so that three of the large or six of the small freight containers will fit aboard a 50-foot freight car of standard equipment. The containers in both classes of car into grooves that prevent shifting in transit.

THE BRUNNER, MOND DECISION

THERE has been much interest expressed in the suit brought by one of the stockholders of Brunner, Mond and Company who would restrain the company from making a gift of one hundred thousand pounds for educational purposes. The matter first gained publicity through the difficulty with which the directors obtained their first vote authorizing that this fund be made available for the furtherance of research, since in the first meeting the recommendation of the directors was voted down only to be carried at a subsequent meeting. The suit was brought on the ground that the company had no right to spend money except for its own benefit and since the support of research would not only benefit the company but necessarily a number of others, the proposal to establish the fund was contrary to laws governing the action of the directors in the utilization of corporation funds. Fortunately for research and education, the action has been dismissed by the judge and preparation had been made to appeal the case to the House of Lords should an adverse decision have been rendered. Plans were under way, also, to introduce a plan in Parliament to legalize such gifts. It has become recognized both abroad and at home that our educational institutions cannot train sufficient chemists and other scientists without generous donations not only from individuals but from corporations and it is very fortunate, therefore, that this precedent should have been established through process of law.



HOISTING ONE OF THE COMPARTMENTS OUT OF A MOTOR TRUCK AND LOADING IT UPON THE RAILROAD CAR



LEONARDO DA VINCI'S FLYING MACHINE A. D. 1490, FROM A MODEL IN THE U. S. NATIONAL MUSEUM AT WASHINGTON
Actual size: Length from tip to tip, 24 inches; beam, 12 inches. Total wing surface, 100 square inches.

Leonardo Da Vinci as Aviation Engineer

The Man Who First Suggested the Helicopter and the Motor to Drive Flying Machines

By Albert A. Hopkins

In the March issue of the Scientific American Monthly we touched briefly upon the achievements of Leonardo as a scientist and inventor. There was one subject—aviation—which was left for fuller treatment. This was necessary because of the immense number of drawings and great amount of data which have come down to us.

The following presentation is timely for two reasons: first, the U. S. National Museum has just recreated a model of Leonardo's approved flying machine, and second, there has been great attention recently given to the helicopter of which we have incontestable proof that Leonardo was the real inventor, as will be shown in this article.

The writer wishes at this point to thank Mr. John W. Lieb for coöperation in allowing his magnificent collection of facsimilies of Leonardo's manuscripts, works on Leonardo and other data to be drawn on freely and all the illustrations are from this source except the National Museum model. His own writings are quoted freely in the article as are also the writings of Mr. Edward McCurdy who published a classic article on the subject in the *Nineteenth Century* a few years ago.

We do not know where Leonardo first obtained his idea of aerial flight, but we know he was occupied with the study of the exact workings of the forces of nature in every manifestation and of their application to human purposes. In the case of Leonardo, considered as the pioneer of the modern science of aviation, it is possible to define very narrowly the character of his researches and the nature of his conclusions. A sentence of Otto Lilienthal's, that great explorer in the realm of mechanical flight, who paid for his devotion with his life, expresses succinctly the measure of contempt which the practical inventor is apt to affect for the mere theorist however much he may be indebted to his researches: "To conceive of a flying machine is nothing, to construct one is something, but to make trial of it is everything." That Leonardo put his knowledge of theory to the proof is to be inferred from the only reference to these researches which is found in contemporary record. It occurs in the *De Subtilitate* of that somewhat empirical physician and philosopher, Jerome Cardan, who after including the invention of flight in a list of "the excellent arts which are hidden," continues: "It has turned out badly for the two who have recently made a trial of it: Leonardo da Vinci, of whom I have spoken, has attempted to fly, but he was not successful; he was a great painter." The laconic antithesis suggests—it almost summarizes—the attitude of contemporary criticism with regard to Leonardo's scientific and mechanical pursuits. The standpoint is the same as that of Vasari, who regarded them as deviations from those purposes which Leonardo alone could accomplish. The criticism has been justified by the march of events. One by one the mechanical and scientific problems to which a great part of Leonardo's creative power was devoted have been solved. He stands revealed as "the forerunner."

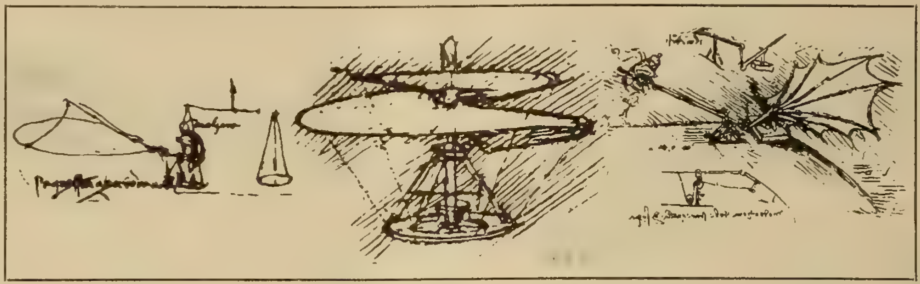
The researches on the science of flight which Leonardo's manuscripts contain are of themselves sufficient to reveal the unflagging zeal with which he devoted himself to the study of primary causes. The subject has given its name to one of the two of his treatises which exist in a more or less complete form (*Il Codice Sul Volo degli Uccelli*); but this would seem to be only an early draft of the results of his observations. It is also treated of in the *Codice Atlantico*, and in seven of the twelve Leonardo manuscripts which are now in Paris in the Library of the Institut de France. Some of these references consist of a few lines, or a diagram with a brief note in explanation, but many consist of pages or half-pages of closely written matter, the contents of which are far more voluminous than the writings of any other student of the subject down to Leonardo's time.

The material falls naturally into two groups, the first being a series of investigations of the laws which govern the power of flight as manifested in nature by birds and other winged creatures, the second consisting of deductions from these principles in the construction of a mechanism which should be capable of sustaining man and being worked by him. The interdependence of the two parts of the inquiry is stated with great succinctness in a passage in the *Codice Atlantico:*

"A bird is an instrument working according to mathematical law, which instrument it is within the capacity of man to reproduce with all its movements, but not with a corresponding degree of strength, though it is deficient only in the power of maintaining equilibrium. We may therefore say that such an instrument constructed by man is lacking in nothing except the life of the bird, and this life must needs be supplied from that of man.

"The life which resides in the bird's members will without

doubt better conform to their needs than will that of man which is separated from them, and especially in the almost imperceptible movements which preserve equilibrium. But since we see that the bird is equipped for many obvious varieties of movements, we are able from this experience to deduce that the rudimentary of these movements will be capable of being comprehended by man's understanding, and that he will to a great extent be able to provide against the destruction of that instrument of which he has himself become the living principle and the propeller."



SUGGESTIONS FOR WEIGHING WIND PRESSURE — HELICOPTER OR FLYING MACHINE FOR RISING VERTICALLY — MACHINE FOR TESTING WINGS OF VARIOUS SHAPES

Flight is a natural phenomenon, and consequently its laws are to be deduced by observation of nature. In acting on this principle Leonardo followed the course marked out by Aristotle in the chapters on the flight of birds in the treatise "On the Method of Progression of Animals," with which treatise it is at least reasonable to suppose him to have been somewhat acquainted.

References to Aristotle in his manuscripts are more numerous than to any other classical writer, and a note in the *Codice Atlantico* allows us to infer that he either possessed or had access to translations in manuscript or works which had not then been printed.

"In order (he says) to give the true science of the movement of birds in the air, it is necessary to give first the science of the winds, which we shall prove by means of the movements of the water: this science is in itself obvious to the senses; it will serve as a ladder to arrive at the knowledge of winged creatures in the air and the wind."

And again:

"Of the bird's movement—in order to speak of this subject it is necessary that in the first book you treat of the nature of the resistance of the air; in the second the anatomy of the bird and of its feathers; in the third the action of these feathers in various of its movements; in the fourth the strength of the wings and tail without beating the wings with the help of the wind to serve as guide in various movements."

And again:

"Before writing about winged creatures, make a book about how inanimate things descend through the air without wind, and another about their descent with the wind."

In treating of the science of the winds he shows how the wind varies in power according to its altitude, as is proved by the fact that birds always fly low when the course of the wind is contrary. The movement of the wind is similar in all respects to that of the water. The rudder behind the ship is copied from the tail of birds; and swimming upon the water teaches men how birds float on the air.

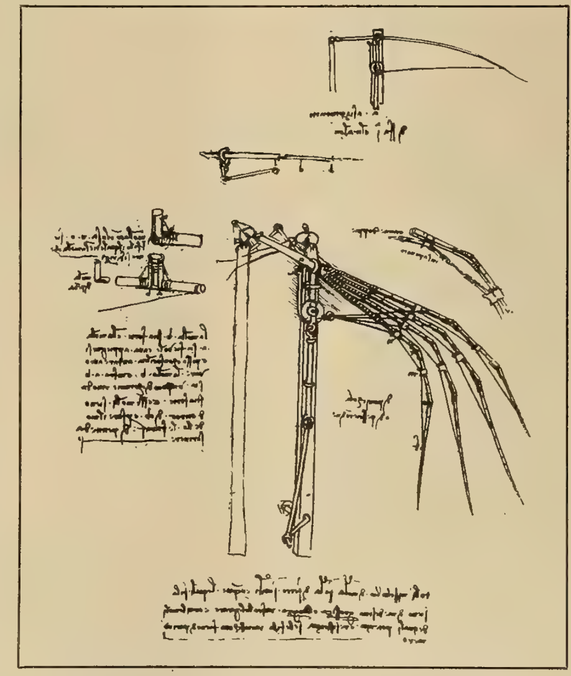
He also defines the resistance of the air, and shows how there is as much pressure exerted by a substance against the air as by the air against the substance; and he shows how the fact of a bird remaining motionless on its wings in the air is due to an equilibrium of forces; and he illustrates how the air beneath the movable substance which descends in it is compressed and the air above it is rarefied.

In his designs we find worked out in small detail, particularly as to the wings and mechanisms for operating and balancing, flying machines with two and four wings, operated by one or more persons with and without mechanical propelling power. We find some driven by spring motors, some by the arms and legs of the operator while lying prone or standing upright. We also find interesting sketches for a screw flying machine or helicopter and a sketch with descriptive details of a parachute.

In reading over the following extract and comparing it with the latest theories of airplane design, we cannot but feel that Leonardo was certainly well aware of the principles underlying aerial flight, in this detail if in no other.

"*To Escape the Peril of Destruction When Flying.*—The destruction of such instruments can happen in two ways, of which the first is that the instrument may break apart; the second would be if the instrument turned itself on edge or nearly on edge, because it should always descend on a very oblique path and nearly on a horizontal line."

We do not know today how many of Leonardo da Vinci's sketches and drawings were actually original designs or inventions, or how many were merely sketches to aid his memory of things he had seen. We do know that some small portion of the material given by Leonardo was not original with him, he having specifically mentioned that this or that device or idea was previously used by such and such a people or individual.



MECHANISM FOR A VERTICAL FLYING MACHINE, DRIVEN BY CRANKS WITH SUPPLEMENTARY WING FLEXURE OR WARPING

It would appear to Mr. Lieb, however, from a study of the manuscripts from an engineering standpoint, that so many of the sketches contain detailed calculations of weights, power required, etc., and so many others contain practical hints, which are really shop instructions for construction and operation, and that many of them could not have been the result of mere observation of apparatus constructed by others, but must have been the result of practical experiment and experience with actual apparatus under working conditions, supporting the contention that a very large part of the sketches are original designs and represent machines actually constructed by him or under his direction.

The first model of a flying machine took the form of a pair of large wings worked by means of the arms, or arms and legs, and attached to the body by a band which passed beneath the armpits.

The type in nature which Leonardo selected to serve as a model was the bat, "because its membranes serve as an armor,

or rather as a means of binding together the pieces of its armor, that is the framework of the wings." (*Sul Volo d. Uccelli.*) He admits that the wings of feathered creatures are more powerful in structure of bone and sinew, but attributes this to the fact that they are penetrable; that is, that the feathers are separated so that the air passes through them, whereas the bat is aided by its membrane, which is not penetrated by the air.

He has also shown that birds like the lark which fly high with the rising of their wings, because these are then pierced through with air, have their feathers spread out more widely than birds of prey which can only rise by a spiral or circular movement. He attempted, therefore, to combine both types by making the wing of the instrument like that of the lark as it rises and like that of the bat as it descends—or, as he calls it, "a method by which the wing is full of holes as it rises and closed up when it falls." This he did by attaching various shutters (*sportelli*) to the surface of the wing. A net connected the framework of the wing to the bamboo canes on which the shutters were fastened along their length on the one side, and on the other side were attached to them by cords at either end. The shutters had rims of cane and were covered over with taffeta, which had been either well soaped or rubbed with starch to render it airtight. As the wing rose the air would pass through the net, and force open the shutter to the extent allowed by the cords. As the wing descended the air below it would drive the shutter up against the net, and so close up the holes, and this would cause the wing to present a solid surface to the air beneath it. He considered that in proportion as the shutters were smaller so they were more useful.

In the second type the instrument has something of the appearance of the body of a huge dragon-fly, tapering slightly toward the tail, and the framework of the wings arched above the head resembles antennæ. Within the body the aeronaut lies at full length, face downward. His feet are in stirrups, which work the wings by means of cords, one of these causing them to fall and the other to rise. Round the neck is a leather band to which a cord is attached, described as "a rudder which is fixed with a band to the head at the place of the neck." The position of the instrument he states to be such that the wings in descending drop partly downward and partly backward, that is toward the feet of the man. The necessity of increasing the power of control led him so to change the mechanism that the wings were lowered by the force of both feet at one and the same time. By this means the downward pressure becomes twice as great and "you are able to delay and to maintain yourself in equilibrium by lowering one wing more rapidly than the other, according to necessity, as you see done by the kite and other birds."

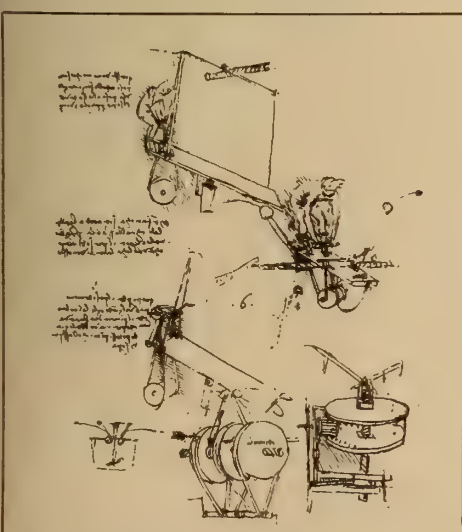
FLYING MACHINE USING ARMS AND LEGS, OPERATOR LYING PRONE, MANEUVERING TAIL BY OPERATOR'S HEAD

The raising of the wings will then, he says, either be by the force of a spring, or by the hand, or by drawing the feet toward you, the last being the best method, because then the hands are left free.

In a passage in the *Sul Volo degli Uccelli* he says that a man in a flying machine should be free from the waist downward to be able to balance as in a boat, so that his center of gravity may balance that of the machine.

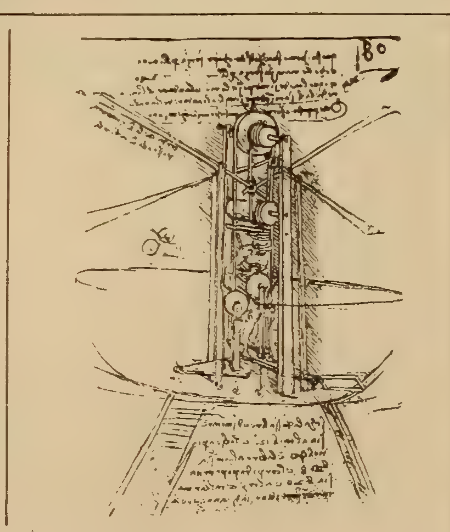
With the various drawings of instruments are notes as to the materials of which the parts are to be constructed. Sometimes a word or more is written in the particular part itself, such as "staff of green pine," "fustian," "taffeta," "try first with leaves of chancery," which latter may be interpreted to mean a form of parchment. Two parts of the covering of a wing are described, one as of "fustian stuck over with feathers," the other of "starched taffeta," and "for the experiment," he continues, "you will use fine pasteboard."

The same forethought prompts a note that the machine should be tried over a lake, and that a long leather bottle



SKETCHES GIVING DETAILS OF THE MANUALLY OPERATED MECHANISM OF THE FLYING MACHINE

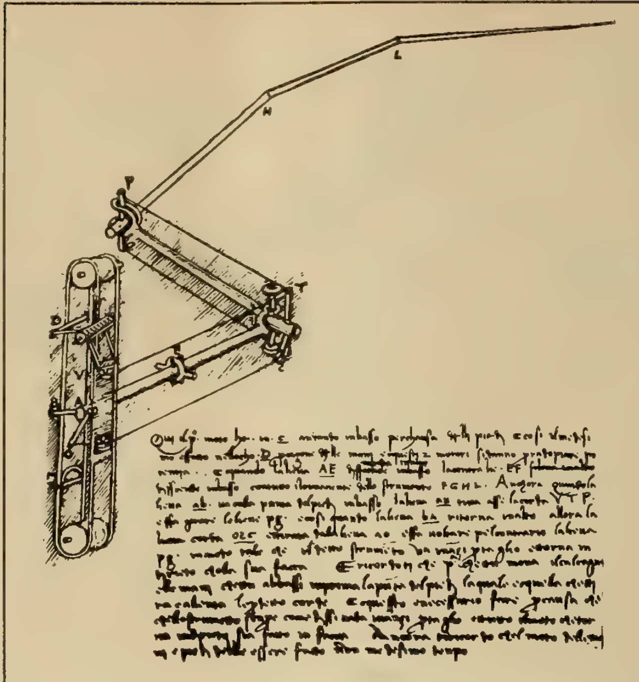
FOLDING LADDER WITH SHOCK ABSORBER FOR LANDING, SHOWING COLLAPSIBLE MECHANISM



A FOUR-WING FLYING MACHINE. OPERATOR STANDING, WITH HEMISPHERICAL BASE AND LANDING

should be carried in the girdle as a safeguard against drowning in case of a fall; and again, in writing of another type of machine, he says: "Try the actual instrument in the water so that if you fall you will not do yourself any harm."

The various notes and drawings which relate to what was probably the latest type of the machine are among the most difficult to interpret. The machinery, although more compact, has become more complicated, and an attempt to define the practical value of the parts of it is only possible to the practised student of mechanics. A drawing of a man suspended by the waist, in an attitude as though swimming immediately below the drum round which the cord is turned, is apparently a preliminary to this latest type: the note below it describes how it may be worked either with one pair of wings or with two, and refers to a ladder or ladders of light thin pine at the base. These ladders are found only in the latest type of the instrument, and he defines their use as serving the purpose of legs when it is desired to rise above a plain, and so rendering it possible to beat the wings. He mentions the instance of the martin, which cannot raise itself by flying when settled on the ground, because it has short legs. A drawing shows how, after the ascent had been commenced, the ladders are to be drawn up so that they lie flat against the bottom of the instrument. They are made with curved ends in order, apparently, to lessen the risk of their becoming fixed in the ground.

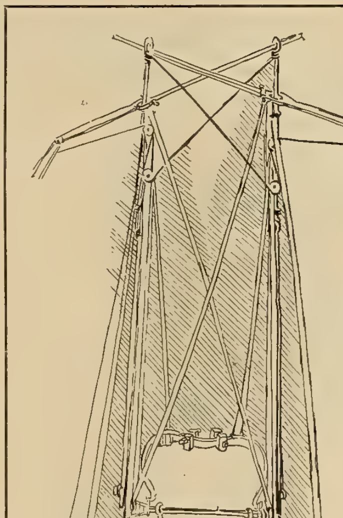


DRIVING AND FLEXING MECHANISM FOR WINGS, WITH UNIVERSAL JOINT

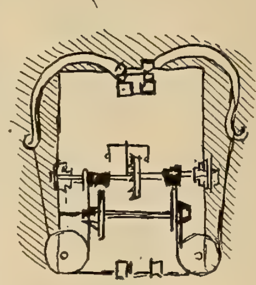
"I conclude (he says) that standing upright is more useful than flat on one's face, because the machine can never turn upside down, and moreover the habit created by long use requires it thus. And the rising and falling of the movement will proceed from the lowering and raising of the two legs, and this is of great force, and the hands remain free, and if one had to be flat on one's face the legs in the fastenings of the thighs would have great difficulty in supporting themselves; and the feet have the first shock when it alights."

A drawing in MS. B of the Institute is the most complete representation of this type of the instrument. In it the figure of the man is seen standing on his feet, but bowed like Atlas under his burden.

Above him are two pairs of wings, which are worked by cords and pulleys controlled by his head and limbs. He is placed between two posts, which support a wheel at the top. Cords passed round it raise and lower the wings as the wheel moves. The posts descend to the base of a low basket-shaped car, where are pedals on which the man stands. These pedals are connected by cords with the wings. The car is resting on short ladders.



A REAL "AIRPLANE," SHOWING IN DETAIL, MECHANISM OF SPRING MOTOR



"FONDAMENTO DEL MOTO"

On a page of MS. B of the Institute is a drawing of a large screw constructed to revolve round a vertical axis. The notes at the side and below the drawing tell of the materials and dimensions, and reveal also the purpose which it was intended to serve.

In its general outline this instrument has some resemblance to certain examples of the type known as helicopters. But both in this and in the earlier model, of which the general structure has somewhat more resemblance to certain types of the modern airplane, the only motive power to be discerned is derived directly from the strength of the human agent. The capacity of the instrument to overcome the resistance of the air is the capacity of his muscles to lift weights and to endure pressure, transferred to this particular purpose by the use of suitable implements. Numerous passages in the manuscripts show that Leonardo doubted the adequacy of this power to accomplish more than short experimental flights. He contrasted it with that reserve of power possessed by the larger birds, and he sought for a fresh source of motive power to supplement or take the place of that exerted by man.

M. Govi, who first called attention to the significance of these passages in a paper presented to the French Academie des Sciences, speaks of them as proving not only that Leonardo invented the screw-propeller, but that he had considered its application to aerial navigation, and that he had constructed small paper models for this purpose which were set in motion by fine bent steel wires.

The function of springs in the machinery of some of the flying machines is shown in two important drawings of a flying machine on a page of the *Codice Atlantico.* These show a machine of the vertical type with a planimetric sketch of the base, within which is written *fondamento del moto.* These, together with an elaborate study of the mechanism of the right wing represent the ultimate stage of the conception as found in the manuscripts —which stage is separated from those which preceded it by the addition of mechanical motive power. To this instrument the architect, Luca Beltrami, does not hesitate to apply the word "aeroplane."

"The apparatus consists of a rectangular horizontal plane, from the middle of the longer sides of which rise two vertical struts made firm by two sup-

ports crossed diagonally. The vertical plane so formed is made rigid by two pairs of supports which connect the upper extremities of the struts with the angles of the plane of the base. Two strong springs, each fastened at one end to the center of one of the lesser sides of the horizontal plane, are bent round its sides by means of ropes, which by the interposition of pulleys are made to turn round a horizontal axle placed at the base of the two shafts; a cog-wheel situated in the center of this axle allows the force stored up in the springs in tension to be able gradually to relax the rope, so causing the revolution of a second axle parallel to the first, and at the extremities of this are cranks for the purpose of moving the wings. These wings are poised at the upper extremities of the shafts, the right wing being fixed upon the left shaft and *vice versa,* so that the space between the two shafts, along which the motive power is exerted, forms the arm of a lever of which this power may avail itself." Each wing is moved by a vertical rod which is looped to the shaft by two rings, and gliding through these it may be raised and lowered according as the fastening to one of the above-mentioned cranks is loose or tight. The lowering of the rod not only moves the arm of the lever, of which the wing is a continuation, but displaces a pulley which turns the cords that correspond to the various loose sinews, which together make up the subsidiary structure of the wing: consequently, as the wing is raised and lowered, these sinews and the surface of the wing are expanded and contracted.

All this relates to constructional details of the instrument. Signor Beltrami, in a few sure words, shows how these parts would be controlled by the human agent:

"The man who guided the machine had his place in the part of the horizontal plane enclosed within the two springs where the words *fondamento del moto* (foundation of the motor) occur in the sketch. He had the cog-wheel in front of him, and could by a simple turn so adjust its revolution as to allow the ropes pressed by the springs to relax gradually and at his pleasure, and so cause the revolution of the axle where are the two cranks which communicate with the wings: as the slackening of the rope is quicker or slower, so the beating of the wings is more or less rapid, and so the flight is controlled."

If Leonardo did not enter the Promised Land, here, surely, he had a Pisgah-sight of it! In arriving at this stage he was separated from that of ultimate attainment only by the lack of knowledge of a light motor with power sufficient to move the mechanism, such as has only been rendered possible by the use of the explosive engine.

An enigmatic sentence on the cover of *Sul Volo degli Uccelli* which was written in 1505, refers apparently to an attempt at flying which was then shortly to take place:

"The great bird will take its first flight upon the back of the Great Swan* filling the whole world with amazement, and filling all records with its fame; and it will bring eternal glory to the nest where it was born."

*This refers evidently to a mountain near Florence which was known as the "Swan."

"The Automatic Pilot"*

New Airplane Stabilizer That Is Part Electric, Part Pneumatic and Part Aerodynamic

While it must be admitted that the number of aviation accidents directly due to failure on the part of the pilot is extremely small, it is none the less desirable that any means provided to lessen the possibility of such failures should be considered on its merits. A short airplane flight, carried out in normal circumstances, is not a particularly fatiguing operation so far as the pilot is concerned, but a prolonged journey in gusty or misty weather subjects him to a degree of mental and physical strain which it is certainly desirable to avoid by mechanical appliances if possible. We have recently had an opportunity of examining a device, the invention of M. Georges Aveline, which has been fitted to a Handley-Page passenger airplane and is capable of relieving the pilot of the whole work of balancing the machine except during the operations of getting off and landing. The pilot, for practically the whole of the journey, need thus only keep his feet on the rudder bar in order to keep the machine on the correct compass course set, the ailerons and elevator being operated by the apparatus which we propose to describe.

Fig. 1, on the next page, indicates the principle of that part of the apparatus which controls the ailerons, and is mounted transversely in the cockpit or other convenient part of the airplane. The essential part of this device is a disc of red fiber in which a circular channel is formed, the channel being about half filled with mercury. Just above the surfaces of the mercury in the channel an electrical contact is fitted on each side of the disc, and another contact is made with the mercury at the lowest part of the channel; if the machine tilts laterally on either side the circuit between the lowest contact and the contact on that side will thus be completed through the mercury. The upper contacts of the mercury channel are connected to the two coils of a relay and when the circuit is completed through one of the contacts, this relay closes a 12-volt circuit in which are the solenoids controlling the inlet and exhaust valves of a servo-motor worked by compressed air. This servo-motor, as shown in Fig. 1, contains two opposed pistons connected by a rack, and the rack gears with a quadrant connected to the aileron control wires. When air is admitted to one end of the servo-motor and the exhaust valve at the other end is opened, the pistons move, turn the quadrant, and so operate the ailerons to correct the tilt. As shown in Fig. 1, the disc containing the mercury channel is also geared to the quadrant, so that it turns in the opposite direction and, by this means, the contact is broken and the pistons brought to rest after moving a distance corresponding to the amount of tilt. It should also be explained that the rate of movement can be regulated as desired by means of a valve fitted in the exhaust pipes.

An interesting feature of M. Aveline's invention is the means adopted to counteract the effects of centrifugal force, but to understand the effect of this part of the apparatus it is necessary to consider its action during a turn. To turn the machine, the pilot moves the rudder bar with his foot, and the machine immediately commences to swing round in a more or less horizontal plane—say to the right. The resulting centrifugal force causes the mercury to rise in the left-hand arm of the mercury channel making a contact on that side, and the effect of this is to pull down the outer aileron and raise the inner aileron, thus causing the machine to bank in the correct manner. The fiber disc, of course, moves in the opposite direction to the quadrant and would break the electrical connection and leave the ailerons in the positions above described but for the special device we shall refer to in a moment. It must, however, first be explained that, as soon as the correct banking is reached, it is necessary to replace the ailerons into the neutral position, otherwise the banking would become excessive and the machine would probably side slip. To avoid this, the arrangement illustrated diagrammatically in Fig. 2 is employed. A Venturi tube is mounted on each tip of the upper wing of the machine and the throats

*Reprinted from *Engineering* (London), Feb. 11, 1921.

of the tubes are cross-connected to the arms of the mercury tube as indicated in the diagram. It will be obvious that the suction from the Venturi tube on the outer wing tip will be greater than that from the other tube since the former is moving faster than the latter, and the effect of this will be to raise the mercury in the inner arm and make an electrical contact on that side. By this means the ailerons are returned to the mid position, and the machine continues to travel on a properly banked turn until the rudder bar is again moved by the pilot, when the reverse action takes place, bringing the machine back to a horizontal straight-line path.

The apparatus for controlling the elevator is generally similar in principle to that used in connection with the ailerons, the main distinctions being that the plane of the mercury channel is mounted in a fore and aft direction and that one arm of the mercury tube is connected to a Venturi tube in the center of the machine, while the other arm is open to the atmosphere. The arrangement of this part of the apparatus is indicated by the diagram, Fig. 3. In normal flight the position of the mercury would be as shown in the illustration, the forward arm being at a higher level than the after arm owing to the suction of the Venturi tube. The pilot has to adjust the fiber disc so that the electrical contacts are just above the level of the surfaces of the mercury in the arms and any alteration in the speed, or fore and aft inclination, of the machine will then complete the circuit to a relay and servo-motor similar to that already described, thus effecting the necessary adjustment of the elevator. It is equally possible for the pilot to set the disc for any desired angle of climb and the machine will then continue to climb at this angle until the disc is readjusted for horizontal flight. In the event of engine failure while the fore and aft automatic control is in use, the drop in speed and the consequent diminution in the suction from the Venturi tube, will allow the mercury to fall in the right-hand arm of Fig. 3 and rise in the left-hand arm. In this way the servo-motor will be operated to put the machine into a downward glide without any action on the part of the pilot, who would only have to steer the machine to a possible landing ground and flatten it out just before alighting.

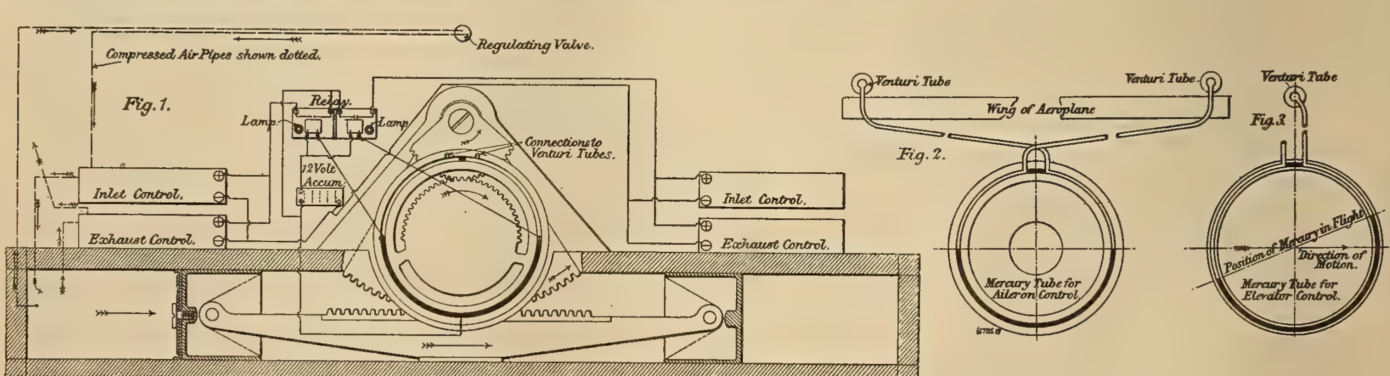
If it is desired to control the machine in the ordinary way, either or both the servo-motors can be instantly put out of action by the pilot, without leaving his seat, by means of valves fitted in the compressed-air pipes or by slackening the cables connecting the quadrants with the main control cables. If the former method of disconnection is adopted the apparatus can still be employed as an inclinometer to indicate a tilt in either the longitudinal or lateral directions. This is due to the fact that small incandescent lamps are included in the circuits connecting the mercury channels with the relays. The lamps are fitted in the front of the relay casings, which are mounted on the instrument board in the cockpit in full view of the pilot. When the machine is flying level laterally, or at the correct longitudinal inclination, all the lamps are extinguished, but a slight tilt in either direction, by disturbing the level of the mercury, will cause one or other of the lamps to light up and indicate the existence of the tilt to the pilot.

The compressed air required to operate the servo-motors is provided by two small wind-driven rotary pumps mounted on the bottom longerons on both sides of the fuselage. These pumps maintain a pressure of about 60 pounds per square inch in a cylindrical reservoir placed inside the fuselage. The reservoir also serves as a receptacle for oil for the rotary pumps, these, of course, requiring constant lubrication. A maximum pull of 500 pounds can be produced in the cable attached to the quadrant, this pull being ample for the control of the largest machines at present in use.

The principal objection to the use of apparatus of this kind is, of course, its weight, since the maximum paying load must necessarily be reduced to some extent. The actual weight of the complete installation on the Handley-Page machine above referred to, amounts, we are informed, to 150 pounds, which is about equal to the weight of one passenger. This, however, is hardly so serious as appears at first sight, since the passenger-carrying capacity of a large machine is usually limited more by considerations of space than of weight, and, moreover, it is an unfortunate fact that the machines are rarely loaded to their full passenger-carrying capacity. Another point in favor of the apparatus is that its use would probably avoid the necessity for employing an assistant pilot on a long journey with a large machine, and this fact would more than compensate for the weight of the apparatus. It should also be mentioned that, in later designs, the inventor expects to reduce the weight of an apparatus of equal capacity to about 100 pounds, and a device designed for use on small two-seater or three-seater machines weighs only 20 pounds. In this, however, the use of compressed air is avoided, the servo-motor being replaced by an ingenious friction gear driven by a small windmill. The invention appears to us to be especially useful in flying through clouds, as well as in night flying, and the fact that the Air Ministry, after extensive trials, have had it fitted on 12 Handley-Page bombing machines for the Royal Air Force, indicates that they are satisfied as to its practicability.

A DEVICE FOR MEASURING THE INTERNAL DIAMETER OF GLASS TUBING

The instrument consists of a thin-walled brass tube inside which a rod carrying a cone at its lower end slides. At the bottom of the tube is a brass ring carrying three wires stretching upward, with a phosphor bronze ball at the end of each wire, suitable holes and slits being provided in the sides of the tube to allow free play to the balls and wires. When the instrument is placed inside the neck of a flask the rod is pushed down until the cone at the end of it can descend no further owing to the balls being pressed against the inside of the flask neck, when the diameter can be read off from the scale engraved on the top of the rod.—Abstracted by *The Technical Review* from *Journal of the Society of Glass Technology*, Oct., 1920.



FIGS. 1-3. DIAGRAMS ILLUSTRATING THE OPERATION OF THE AVELINE AUTOMATIC STABILIZER FOR AIRPLANES

The Nature of Vowel Sounds*

The Laryngeal Puff Which Distinguishes the Musical from the Unmusical Quality of Voice

By Prof. E. W. Scripture

SINCE the time of Wheatstone and Helmholtz the vowels have been almost universally supposed to obtain their tones by acting as resonators to certain overtones of the larynx tone. Helmholtz even constructed an apparatus of a set of harmonic tuning-forks by combinations of which he hoped to produce the vowels. Ever since the invention of the speech-recording machine by Scott and Koenig in Paris the analysis of vowel curves has been expected to solve the problems of the nature of a vowel and of the differences between different vowels.

At the present day the vowels can be recorded on talking machines, and their curves can be traced off with an accuracy that leaves nothing to be desired. The work of Hermann on the curves of the vowels and consonants by means of the phonograph is still unsurpassed. For my own investigations the gramophone was chosen as the most available machine.

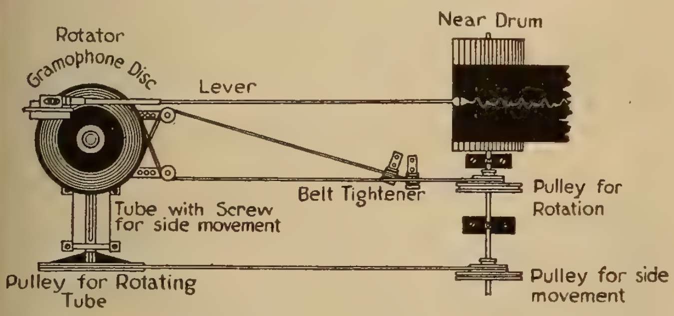


FIG. 1. APPARATUS FOR TRACING GRAMOPHONE CURVES.
A steel needle near one end of a long lever follows the groove. Its movements are enlarged 500 times and registered on a band of smoked paper.

A disc with the desired record was placed on a very slowly revolving plate (Fig. 1). A long lever of Japanese straw was held in an axle at one end. Near this end a steel point projected downward into the speech groove. At the other end there was a recording point made of a fine glass thread. As the disc revolved, the movements were magnified—up to 500 times—and traced on a moving band of smoked paper.

Pieces of vowel curves cut out of a tracing of a record by Joseph Jefferson are shown in Fig. 2. The curves show that in speech the vowels change constantly in pitch, in intensity, and in character. They also show that the vowels actually used in speaking are often not what the phonetician supposes them to be.

The point of interest on the present occasion, however, is the nature of a single wave of a vowel. At the present day there is only one way of analyzing a wave—namely, the harmonic analysis. Any wave can be represented as made up of a series of simple sine waves with the relations of frequency of 1:2:3: . . . and with various amplitudes. A harmonic analysis of the wave in the top line of Fig. 3 gives the four curves in the lines below. This means that the four curves, if added together, will give a result like that in the top line.

Suppose, now, that we have a curve that consists of a vibration repeating itself every 3½ times to a wave. The harmonic analysis gives as result a fairly strong fundamental of the frequency 1, a stronger vibration of the frequency 2, a still stronger vibration of the frequency 3, a somewhat less strong vibration of the frequency 4, and ever-lessening vibrations of the frequencies 5, 6, 7, etc. Not one of these vibrations was actually present in the original curve. The strength of the original vibration of 3½ could not be directly given, because there was no place for it in the harmonic series.

The harmonic analysis shows us how a given curve can be represented as made up of a series of harmonic components; it does not say that it was originally so produced. Such a deduction has to be made on other grounds. The familiar experiment with a piano string touched lightly in the middle, then at one-third of its length, etc., shows that it vibrates in harmonic parts; an analysis that gives the harmonic components in various amplitudes can be accepted at once as indicating the strength of the components. An analysis, however, that gives all the harmonics as being present to some degree with a bunch of strong ones at one or more points would indicate at once that one or more inharmonics were present.

A harmonic analysis of the wave in Fig. 4 from the first vowel in "Marshall" gives the harmonic plot shown in Fig. 5. This merely states that the original wave can be reproduced by using harmonics in the relations indicated. The deduction concerning how the wave was originally produced is left for the person who interprets the harmonic plot.

If such a result were obtained for a wave from a musical orchestra, we should have no hesitation in concluding that the wave was produced by a summation of vibrations in the harmonic relation. If the wave originated from a single source, we should certainly not be justified in drawing the same conclusion without further evidence. In seeking for further evidence we find, in the first place, that the waves

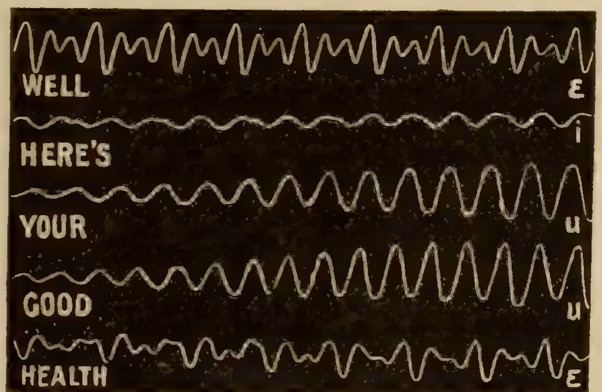


FIG. 2. VOWEL CURVES. THE WAVES FALL INTO GROUPS.
The top line contains eight groups, the next line six, the third seven, the fourth eight, and the last seven. Each group corresponds to one vibration from the larynx. The length of a group gives the pitch of the laryngeal tone; in speech this is always rising or falling. The height of the waves indicates the intensity. This is nearly always small at the beginning of a vowel; there is a steady rise to a maximum and then usually a fall to the end. The small waves within a group give the characteristics of the vowel sound. The top line is a piece out of the middle of the vowel in "well." The second line is from the vowel in "here." The third is near the beginning of "your." The fourth is the first part of the vowel in "good." The last is from the middle of "health." In the second, third, and fourth cases there is evidently present a tone more or less nearly the octave of the laryngeal tone. The other tones and the tones in the other cases can be found only by analysis.

from musical instruments so far as yet studied—the material is extremely limited—do not give harmonic plots like that in Fig. 5, and do give plots having one, two, or three prominent harmonics with the others lacking. This would agree with the known fact that most musical instruments vibrate in harmonics. If the source of the wave were absolutely unknown, the most plausible deduction would be that it was some body or bodies that might vibrate in either harmonics or inhar-

*Reprinted from *Nature* (London), Jan. 13 and 20, 1921.

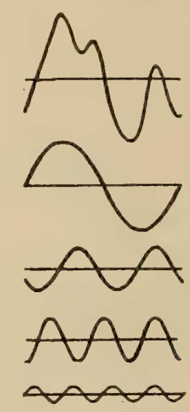


FIG. 3. A CURVE COMPOSED OF FOUR SINUSOIDS

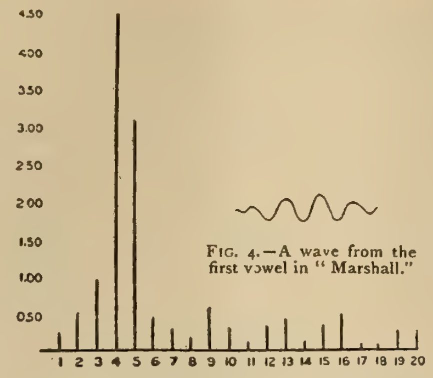


Fig. 4.—A wave from the first vowel in "Marshall."

FIG. 5. RELATIVE AMPLITUDES OF SINUSOIDS FOUND BY HARMONIC ANALYSIS

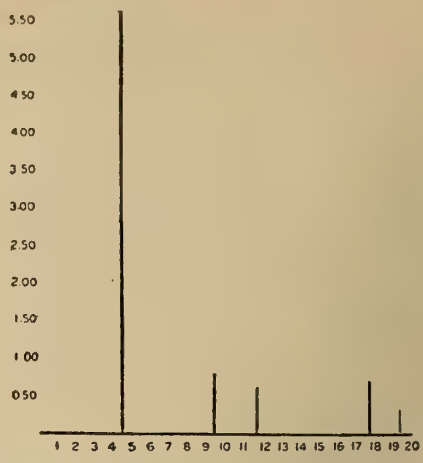


FIG. 6. RELATIVE AMPLITUDES OF COMPONENT INHARMONICS DEDUCED FROM FIG. 5

monics. We should take the weighted means of the groups of strong harmonics, and should find in this case that the components were the inharmonics

1 :4.3 :9.3 :11.5 :17.6 :19.5.

The result can be expressed in the inharmonic plot in Fig. 6. This conclusion is of vital importance, because such results are just those that are always obtained from careful vowel analyses. The very harmonic analysis itself leads to the conclusion that the vowel tones may be inharmonic.

In the analyses of vowel waves the fundamental is indicated as weak (as in Fig. 5) or often almost lacking. This fundamental represents the voice tone or the tone from the larynx. We all know that this is the strongest tone of all. We may not be able to hear just what vowel a speaker or singer is producing, but we certainly know whether he is using a high or a low tone of voice. One writer, observing this peculiarity in the analysis of the waves obtained from a phonograph, remarked that this instrument must be deaf to the voice tone. He failed to consider that if it was deaf to this tone it could not reproduce it, and that even the most defective phonograph will produce the voice tone so long as it makes any noise at all. The weakness of the fundamental in Fig. 5, therefore, does not show that the fundamental was lacking in the original vibration.

Let us inquire what kind of a strong tone will appear in the harmonic analysis with a weak fundamental. This is the case with a series of sharp puffs. If the period from one puff to the next of a series is subjected to harmonic analysis, the result shows a weak fundamental with all the higher harmonics represented in ever-diminishing amplitudes. The fundamentals in the vowel curves are therefore not of the nature of sine vibrations, but of series of more or less sharp puffs.

This is not a new theory of the vowels. In 1830 Willis published, in the Transactions of the Cambridge Philosophical Society, a paper on the tones of the vowels and reed organ-pipes. He asserted that a vowel was composed of a series of puffs with a set of inharmonic overtones. This was rejected in favor of the harmonic theory by Wheatstone, whose conclusions were accepted and developed by Helmholtz. For nearly a century the harmonic theory has been universally accepted. In a series of researches beginning in 1889 Hermann found that the analyses of phonograph curves showed the vowels to be constructed of puffs and inharmonics. He thus independently rediscovered the principle of Willis. This theory has been substantiated and developed by thousands of analyses in my work for the Carnegie Institution of Washington, and published in *The Study of Speech Curves* (Carnegie Inst. Publ. No. 44), from which the above results are taken. It should be added that this extensive and somewhat expensive work was made possible by the support of Yale University and the liberality of the Carnegie Institution of Washington.

THE MANUFACTURE OF VOWELS

For the manufacture of vowels Helmholtz used tuning-forks that gave smooth vibrations and not puffs; moreover, the only overtones tried were harmonic to the fundamental. Some years ago I made an attempt to manufacture vowels on the principles discovered by the analysis of vowel curves.

The fundamental was produced by a puff siren (Fig. 7) similar to the familiar one of Seebeck. As a slit passes across the blast tube a jet of air issues for an instant. This is heard as a faint puff. As the disc is rotated more rapidly the puffs come oftener, until at one region a low tone appears. With still greater rapidity the pitch of the tone rises.

When a brass resonator is placed in front of the tube of the siren it sounds loudly when the frequency of the puffs is the same as that of the tone of the resonator, and also less loudly when it is in some other harmonic relation. For inharmonic relations the resonator is silent. Resonators with hard walls, therefore, cannot be used to produce sounds containing inharmonic components.

The soft-walled resonators of the mouth can be imitated by spreading pieces of meat over wire frames. As this has its inconveniences, a wire frame may be covered with a layer of absorbent cotton soaked in water. Such a resonator is shown in Fig. 7. The walls are quite inelastic. When such a water resonator is placed in front of the tube of the siren, it responds equally well to all tones of the siren, whether harmonic or inharmonic. Two or more resonators can be combined to meet the requirements for various vowels.

The theory of this vowel siren can be illustrated by the diagrams in Fig. 8. The puffs come as sharp blows almost instantaneous in character; they are indicated by the crosses. When such a blow strikes a resonator with soft walls, it arouses a vibration in the cavity that dies away very rapidly, as is indicated in the first line of the figure. The vibration is entirely gone before the next puff hits it. The response of the resonator is quite independent of the frequency of the puff. When, however, a puff strikes a resonator with hard walls, it arouses a vibration that dies away very slowly. When the next puff comes, the result depends on its relation to the vibration still going on in the cavity. If the puff hits the resonator at a moment when its frequency would be a submultiple of the frequency of the resonator, then it will reinforce the vibration and make the resonator tone louder. This is illustrated in the second line of the figure. If, on the other hand, it hits the resonator at a moment one-half a period short of a harmonic relation, it will kill the vibration it finds. A very weak tone may be aroused by puffs with a

frequency that is not a sub-multiple of the frequency of the resonator, but no strong response can be obtained outside the harmonic relation.

The siren with water resonators was constructed with the aid of Hodgkins fund of the Smithsonian Institution of Washington. It produced most of the typical vowels with success. Under the Carnegie Institution the work was continued with an attempt to imitate more closely the conditions in the living body. Although the cheeks can be represented by water resonators, the roof of the tongue is somewhat more difficult; the roof of the mouth is quite an approach to a hard resonator. To imitate these conditions, a resonator was made of a skull supplied with cheeks and a tongue of gelatine. The tongue was removable, so that models of different forms could be inserted. The voice tone was obtained from a vox humana organ-pipe. The ultimate object was to find vowel resonators that would respond with specific vowels to any tone. These were then to be mounted on a reed organ as an extra register. All tones issuing from the organ could be made to pass through one of the vowel cavities, and the organ would thus sing the vowels. In most singing the consonants are a subordinate matter, and such an organ would aid the singing of a choir or a congregation. The beauty of such a vowel register in a large organ in a cathedral is quite beyond imagination. This investigation was also supported by the Hodgkins fund, but was discontinued on account of the work required for the study of speech curves.

THE STRUCTURE OF VOWELS

The study of speech curves and the making of vowel-producing instruments show that two groups of elements are to be found in a vowel.

The first is the voice tone. Three properties of this tone are to be considered. The pitch of the tone is given by the rapidity with which the laryngeal puffs are repeated. If V indicates the number of puffs per second, then $V = f\ (t)$ is the general expression of the fact that the pitch of the voice tone depends on the elapsed time. It might be supposed that, in singing a vowel on a given note, the pitch would remain constant. A study of a record by the tenor Caruso (not yet published) shows that he never keeps his voice on a constant pitch during a vowel, but makes continual small changes. A study of the vowel "oh" used as an interjection shows that the pitch of the voice tone changes to express the emotion and the meaning of the interjection according as it is spoken to express sadness, admiration, or doubt. In fact, it is quite possible to obtain an equation for V for each of the three cases. In ordinary speech the pitch of the voice tone changes from instant to instant. Every individual vowel has a melody of its own. This melody varies with the emotion, the meaning, and possibly other factors.

The intensity of the voice tone depends on the energy of the puffs from the larynx. If I indicates the puff energy, then $I = f\ (t)$ expresses the fact that the intensity varies from moment to moment. The speech curves show changes of intensity that express emotion and meaning. Even in song—as Caruso's curves show—the intensity is constantly varied in a way that makes his song a production of art, and not a mechanical performance.

The third factor of this group is the musical character of the voice tone. This depends on the *shape* of the puff from the larynx. The matter is of such importance that the following statement seems to be needed.

After a tuning-fork has been struck its vibrations slowly die away. Its curve is really not that of a simple sinusoid, but that of a frictional sinusoid

$$y = a.\ e^{-\epsilon t} \frac{2\pi}{T} t, \ldots\ldots\ldots\ldots\ldots\ldots (1)$$

where y is the elongation at the moment t, a the amplitude or maximum elongation, T the period, e the basis of the natural system of logarithms, and ϵ the factor of friction or damping. The period T is affected by the factor of friction, but the amount is so small that it can be neglected here. The effect is to cause a decrease in the amplitude. When the value of ϵ is great, the curve is that of a sharp puff. When it is less, the puff is more gentle. If it were o, the ordinary simple sinusoid would be obtained.

The puff from the larynx may be of a complicated form that should be represented by the sum of a series of frictional sinusoids. The complete equation would be

$$y = \Sigma a.\ e^{-\epsilon t}\ sin\ \frac{2\pi}{T}\ t. \ldots\ldots\ldots (2)$$

This comprises the whole of the vibration of a single puff. It is a free, and not a forced, vibration. The musical or unmusical quality of the voice depends solely on the presence or absence of the various members of (2). The quality of the voice that distinguishes a Caruso from a costermonger lies exclusively in the laryngeal puff. This fact is of importance as contradicting the almost universally accepted theory of vocal training that is based on "tone-placing" by the supposed action of the vocal cavities as resonators to give the musical quality to the tone from the larynx.

The other group of elements comprises the tones aroused in the vocal cavities. A puff striking a cavity arouses one or more vibrations of the form of a frictional sinusoid as in (1). Each cavity will have its own factor of friction and its own period. As shown by the vowel siren, this response will be a free vibration independent of the voice tone and the periods that go to the vibration that makes up the puff. Every change in the sizes or openings of the cavities will alter the periods of these vibrations. The possible combinations for the cavities of the chest, pharynx, mouth, and nose provide for an almost endless variety of vowels.

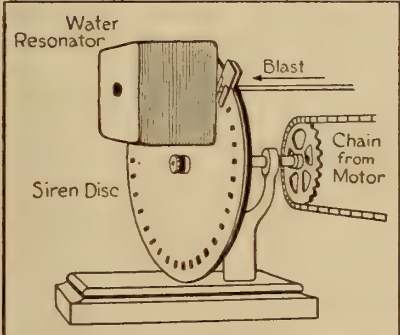


FIG. 7. PUFF SIREN WITH WATER RESONATOR

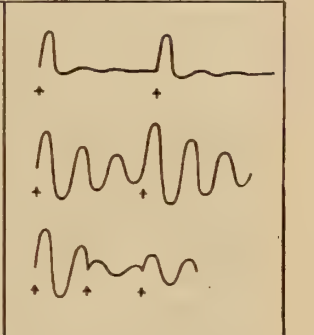


FIG. 8. VIBRATIONS IN RESPONSE TO PUFFS

The puffs are indicated by the crosses. The first line shows the response of resonator with soft walls. In the second line the puffs hit a resonator with hard walls in such a way as to maintain strong vibrations. In the third line the puffs hit the same resonator in a way to produce little or no effect.

The speech curves show quite unexpectedly that there is no such thing as a constant vowel. The vowel "o" in "so" changes its specific vowel character from beginning to end. The least change is found in German; more change appears in American. There is so much change in English that an American hears the vowel "o" as a sound starting like "oh" and ending like "oo." The statement that this English vowel is a diphthong composed of two vowels is incorrect. The vowel is a single sound that gradually changes greatly in character. There is no objection to calling it a diphthong provided it be recognized—as the speech curves show—that all diphthongs are really single vowels that change greatly in character. At the same time, it must be recognized that what is called a single vowel may change even more in character than a so-called diphthong; the change in a very short vowel, as in "but," is often surprising.

Just what constitutes the differences between the different vowels is a problem at present beyond the reach of science. The ear tells us that there are many sounds which we group

together under the type "ah"; many others that would go to form the type "oo," etc. The speech curves show that the multiplicity of varieties under each type is almost beyond belief. In a general way we know that the impression from "ah" is that of a higher tone than from "oo," from "ee" higher than from "ah," and so on. All details of the tones in a single vowel are lacking. Every investigator has differed from every other one in regard to what tones constitute any particular vowel. As shown in this article, we can get so far as to say on what principles a vowel is built up. We can even get curves of the vowels of an accuracy that leaves nothing to be desired. We have not, however, any method of analyzing these curves accurately into a series of frictional sinusoids with independent periods and factors of friction. We must probably wait for some mathematician to do for this problem what Fourier did for harmonic motion.

DUPLICATING THE CUBE—ALMOST

EVERY little while we are called upon to pass on the work of somebody who thinks he has resolved the problem of squaring the circle, of duplicating the cube, or of trisecting the angle. These claims fall into two distinct groups. There is the man who has a construction that will really do what he thinks it will, but which is not itself a Euclidean construction. Nobody, we suppose, would claim to have squared the circle by rolling it through a complete revolution and measuring the line thus generated; yet cubes are duplicated and especially angles are trisected by stunts that are equally wide of the recognized rules of the game, and the perpetrators of these stunts demand recognition as having put to shame the integrated mathematical ability of twenty centuries.

Then there is the man who has a construction that he can really carry out with compass and ungraduated straight edge, and which comes so close to a numerically exact trisection or duplication or evaluation of *pi* that he mistakes approximation for achievement and claims to have solved the age-old riddle. Some of these demonstrations are marvels of draftsmanship, being the fruit of a figure so complicated that it is only with the greatest difficulty that one can follow the various steps and keep a clear idea of what has been proved and what remains to be established. Sometimes, on the other hand, a remarkably close approximation flows out of an extremely simple construction; and a case of this sort possesses a certain degree of inherent interest. Mr. James Smith of Brooklyn has recently put before us an approximate construction for duplicating the cube which stands at the head of this class, and which we reproduce herewith.

Let OC be the side of the given cube. Bisect OC at S, and complete the square OSKA. With radius KC and centers K and C, strike arcs meeting at P. Bisect OA at Q. Then the line PQ represents, to all intents and purposes, the side of the cube whose volume is double that of the cube on OC.

For the purpose of subjecting the construction to analysis, we take O as origin, OA as x-axis, and OC as y-axis. Let $OC = 2s$; then $OS = OA = s$. The point K has coordinates (s, s) and the point C has $(0, 2s)$. The distance $KC = s\sqrt{2}$. For the circles about K and C called for in the construction we have the equations

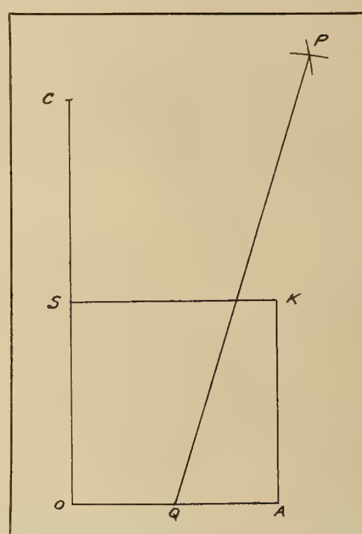
$$(x - s)^2 + (y - s)^2 = 2s^2,$$
$$x^2 + (y - 2s)^2 = 2s^2$$

On simplifying, solving simultaneously, and selecting that intersection which has x positive, we find for the coordinates of P the values $\frac{s}{2}(1 + \sqrt{3}), \frac{s}{2}(3 + \sqrt{3})$. Using the distance formula between P and Q, we get for the length PQ the value $\frac{s}{2}\sqrt{15 + 6\sqrt{3}} = t$. For the ratio of the volumes of the cubes on $2s$ and on t we have

$$\frac{t^3}{(2s)^3} = \frac{\frac{s^3}{8}(15 + 6\sqrt{3})^{3/2}}{8s^3} = \frac{(15 + 6\sqrt{3})^{3/2}}{64}$$

In evaluating the numerator, if we take for $\sqrt{3}$ the value 1.732051, which is a trifle too large, we get for the expression $15 + 6\sqrt{3}$ the value 25.392306. For the square root of this the value 5.0391 is again a shade too great; for the cube of the last-named quantity the value 127.9555 is for a third time a wee bit over the mark. An upper limit for the ratio between the two cubes is then 1.9993.

If for $\sqrt{3}$ we take the value 1.73205 we get $15 + 6\sqrt{3} =$ 25.3923. For the square root of this 5.039 is too small; for the cube of the last 127.94787 is again too small. From this a lower limit for the ratio between the cubes is found to be 1.99918. That a construction of such extreme geometric simplicity should give a non-Euclidean numerical quantity with an accuracy exceeding one-twentieth of one per cent seems quite remarkable.



A SIMPLE APPROXIMATE DUPLICATION OF THE CUBE

NEW MICROPHONE FOR THE DEAF

AN article in *Licht und Lampe* (Sept. 9, 1920), describes an almost unnoticeable form of combined microphone and telephone by means of which defective hearing, short of total deafness, is largely remedied. The telephone transmitter is so very small that it can be inserted in the aural canal, and is then practically invisible. A fine twin flexible runs through the user's clothing and connects this with the microphone, which, with its battery, is mounted in a gentleman's attaché case or lady's hand-bag. The leather of the case or bag is pierced to allow the sound waves to pass freely, but these articles are practically indistinguishable from ordinary ones of their kind. A stud contact on the wrist permits the apparatus to be disconnected when not in use. Several elements can be provided for continuous service, to be switched on one after the other. In use, the bag or case is carried in the hand or laid on a table or counter.—Abstracted by *The Technical Review*.

A SIMPLE PORTABLE REFLECTOMETER

FOR some time the U. S. Bureau of Standards has been engaged in the development of a simple portable reflectometer Recently numerous improvements have been made in this dvice which in its present form may be described as follows: The instrument is a sphere with a small segment cut away leaving a hole over which the surface to be tested is placed. The wall of the sphere is viewed through a small hole by means of a portable photometer, the spot viewed being screened from the test surface. A lighting tube set at an angle to the sphere surface is arranged to rotate about an axis normal to the surface of the sphere so that the direct light can be thrown on the test surface or on the sphere wall.

The theory of the integrating sphere shows that the reflection factor of the test surface is simply the ratio of the photometer readings in the two cases, no assumption being made as to the way in which the light is reflected from the test surface. Moreover, the reflection factor measured is not affected by selective reflection from the sphere walls. No accurate voltage adjustment of the lamps in the photometer and the reflectometer is necessary as both operate from the same battery. The use of a low-voltage flashlight lamp in the lighting tube makes the instrument very portable and convenient. By addition of an exterior light source, the same instrument can be used to measure transmission factors of clear or diffusing media.

Science and National Progress

Edited by a Committee of the National Research Council

Dr. Vernon Kellogg, Chairman, Dr. R. M. Yerkes, H. E. Howe

THE INTERNATIONAL AUXILIARY LANGUAGE PROBLEM

By Ward Nichols

Secretary of the Committee on International Auxiliary Language of the International Research Council

The National Research Council is a cooperative organization of the scientific men of America. It is established under the auspices of the National Academy of Sciences and its membership is largely composed of appointed representatives of the major scientific and technical societies of the country. Its purposes are the promotion of scientific research and of the application and dissemination of scientific knowledge for the benefit of the national strength and well-being.

THE steamship, the railroad, the telegraph and the cable have marvelously increased the facilities for commerce, travel and communication in all fields, and have revolutionized the conduct of business, as well as political and social affairs of the whole world to an extent little dreamed of by the people a hundred years ago. In the early part of the century it required a month to fifty days to make the ocean voyage by sailing-vessel from New York to London—a voyage attended with many dangers and a multitude of discomforts. Today the wonderfully developed steamship, with its double steel hull, divided into many water-tight compartments, with its powerful reciprocating or turbine engines and triple propellers, takes us the same journey in less than a week amid surroundings of comfort and elegance equaled only by the best of the palatial hostelries in our large cities. The port once attained, the railroad then takes us over a river here, under a river there, through the mountain beyond and across the great prairies, constantly striving to lessen distance, save time and to carry heavier loads and make more frequent trips; while the telegraph, carrying simultaneously three and four messages each way where formerly one message one way was the limit, is endeavoring to keep pace with the rapidly increasing business; and by the cable the merchant in New York or San Francisco, Buenos Aires or Valparaiso, translates the business impulse of the moment into almost immediate action on the same day at London, Havre, Hamburg, Shanghai or Yokohama! And who can say what the commercial development of the submarine and the airplane has in store!

Only a century ago Europe was practically the whole of the civilized world: Today the four corners of the earth are our immediate neighbors!

But in spite of the wonderful progress resulting from the development of the mechanical means of intercommunication—greater progress than was made during the previous five centuries—the means of oral and written intercommunication, aside perhaps from the developments in stenography, show no advance over conditions of five hundred years ago. The world has been obliged to carry on the great and constantly increasing volume of international intercourse in many different languages, all of them difficult of acquirement, and all this in the face of the existence of convincing evidence of the practicability and utility as well as the tremendous possibilities of an easily acquired neutral international language!

And the wonder of it all is, that our governments which spend millions upon Suez and Panama canals, that the very men who, as directors in our great national and international corporations, authorize by a nod of the head the expenditure of thousands of dollars to lessen a grade, or to tunnel a mile or two through a mountain to save going around it, who graveyard the Mauritania of today for the Leviathan of tomorrow, all in the name of efficiency, apparently remain blind to the frightful inefficiency and enormous cost of the conduct of modern business with ancient methods of communication.

The need for an international language for the purpose of intercourse between peoples of different speech and nationality was felt long before the present century. Even so far back as 1629, Descartes, though not the author of a project himself, formulated the two principal methods upon which all international language projects have been constructed: (1) the "a priori"[1] method, consisting of arbitrarily selected letters, syllables or words indicating an idea or group of ideas in accordance with a determined classification, and based in no way upon any natural language; (2) the "a posteriori" method, based on roots already existing in the natural language. It is interesting to note that although Descartes himself favored the *a priori* and rejected the *a posteriori* as "fit for vulgar minds," the projects which have thus far acquired an appreciable following have been founded on the *a posteriori*" method.

During the last two centuries there have been over one hundred attempts to solve the international language problem, but up to the advent of Volapük, in 1879, none of them had attracted more than passing notice, and the vast majority never progressed beyond the announcement stage. The history of the subject during the past thirty years may fairly be considered to have brought seriously before the public at large only three projects, and it is particularly interesting to note that while the mutual relations of these three systems have been avowedly competitive, they all have had in practice a common linguistic trend and thus all have served to develop and clarify the problem as a whole.

The project of an international auxiliary language may very properly be regarded as entirely analogous, at least in the first instance, to that of stenography, *i.e.*, as a special tool for special purposes which has no more bearing on the use and spread of existing national languages than stenography has had on that of printing and longhand. On the other hand, while it is relatively inconsequential how many different systems of stenography are in use, since each writer generally transcribes his own notes, the primary utility of an international auxiliary language is destroyed if essential agreement cannot be reached, and effort is consequently scattered among rival projects.

Real progress toward the solution of the international language problem may be said to have begun with the advent of Volapük in 1880. It was the invention of a Roman Catholic Bishop, Johann Martin Schleyer, of Litzelstetten, Baden, who is said to have possessed a knowledge of more than fifty natural languages. The vocabulary was supposed to be based mainly upon the English language, but most of the words were so mutilated as to entirely obscure their origin.

For the first three or four years the movement was largely confined to the German-speaking countries. In 1885 it was introduced into France and attracted a large and enthusiastic following, and the national propaganda society of that country numbered among its members many well-known men of science and letters. From France it spread rapidly into other European countries and into the Americas; and by 1889 there were

[1]A good illustration of the *a priori* method is the project "RO," by Rev. E. A. Foster, published by *The Ro Language Society,* Waverly, West Virginia.

nearly 300 Volapük societies distributed throughout Europe, America and the British Colonies, instruction books had been published in twenty-five languages, including Volapük itself, and the number of adherents was estimated at over a million.

There were three Volapük congresses, the last of which was held at Paris in August, 1889, just at the time when interest in the project appeared to be greater than ever and success seemed to be in sight. Early in the development of the movement dissension arose between Bishop Schleyer and the Academy (founded at the second congress in 1887) over the duties of the Academy and also as to the respective powers or authority of the inventor and the academicians, especially in the matter of the consideration and approval of proposed reforms in the grammar and vocabulary. At the third congress the quarrel was renewed and became so bitter that dissensions arose among the academicians themselves; and from this time on Volapük rapidly declined and within two years the movement was dead.

Although Volapük ended in failure as a project, nevertheless it is a valuable contribution to the linguistic side of the international language problem, and the history of this first significant attempt to solve the question is of great interest: in spite of its philological defects Volapük spread rapidly over the whole of the civilized world, and demonstrated the responsiveness of the world at large to the international language "idea."

In 1893, after nearly four years of inactivity, the Volapük Academy, materially reduced in numbers, again began to function, and under the lead of a new director, M. Woldemar Rosenberger (1893-1898), a St. Petersburg engineer, followed by Rev. M. A. F. Holmes, of Macedon, N. Y. (1898-1908), continued the work of amending and improving the Volapük grammar and vocabulary. The result was an entirely new project which was given the name of Idiom Neutral. In many respects it resembled Esperanto which had in the meantime appeared; in fact M. Rosenberger acknowledged that Esperanto was one of a number of projects which had a material influence upon the labors of the Academy. The language, however, was not used to any extent outside of the Academy itself, largely because of the activity and strength of the Esperanto propaganda. Indirectly, as experimental material, it probably did influence to a considerable extent the production of a later project, Ido.

From 1909 down to the present time Dr. G. Peano, professor of mathematics in the University of Turin, Italy, has held the post of president of the Academy, the organization now being officially known as "Academia pro Interlingua." The Academy gave up its special allegiance to Idiom Neutral and commenced the publication of an official organ called *Discussiones* issued at regular intervals as material becomes available, its columns being open to any international language project which its members may wish to discuss. Professor Peano together with some of his colleagues has worked out a system based essentially on Latin, with simplifications both in grammar and vocabulary, together with an adoption of recognized modern international terms, and a considerable portion of *Discussiones*, including official announcements of the Academy, appear in this form. *Discussiones* suspended publication at the outbreak of the war, but the Academy is again resuming activity as indicated by an 8-page bulletin which appeared in January of this year.

The author of Esperanto was a young Polish doctor, Ludwig Lazarus Zamenhof, born at Bielostock, Poland, December 15, 1859. His incentive was largely humanitarian and was inspired by his observation of the bitter feeling of animosity existing among the four racial elements making up the population of his native city, Russians, Poles, Germans and Jews. The constant state of strife arising from these conditions deeply impressed young Zamenhof, convincing him that diversity of language was one of the principal causes of international hatreds, and led him to the determination to do what he could to unite all men by means of a common auxiliary tongue.

When he was 14 years of age he entered the Second Classical Gymnasium at Warsaw from which institution he graduated in June, 1879, and entered the University of Moscow, graduating in 1885 with the degree of doctor of medicine. During his school and university life he devoted all of his spare time to an endeavor to create an artificial language. His first efforts were toward an *a priori* language with made-up words and arbitrary grammar, but as he progressed with his language studies—and he is said to have mastered Latin, Greek, German, French and English—he became convinced that an international tongue should be based upon roots common to several existing languages, with the simplest possible grammar; and along this line all his future work was carried out.

While still a student at the Gymnasium, he presented his first project tentatively to his companions, but efforts to propagate the language met with ridicule and criticism to such an extent that his parents interfered and he was obliged to promise his father that he would take no further steps publicly with his project until he completed his studies at the university. And so for five years up to the time he graduated from the University of Moscow, nothing more was heard publicly of his scheme, although during all this time he continued the work of perfecting and testing the language.

For two years after his graduation he searched in vain for a publisher who would be willing to print his work, and finally he published it himself under the title of "Lingvo Internacia," by "Dr. Esperanto" (one who hopes), on the 26th of July, 1887, at Warsaw, just at the time when Volapük was nearing the zenith of its success.

At first the new project called forth criticism and suggestions for improvements, to all of which Dr. Zamenhof gave careful consideration. He disclaimed all authority over the language, desiring to be considered merely as its "initiator," but he suggested that improvements should be introduced only after mature judgment and by some "central authoritative institution having indisputable authority for the whole Esperanto world, and not by any private person."

Early in 1889 the American Philosophical Society (Philadelphia) became interested in the international language problem in consequence of the Volapük propaganda, and proposed to arrange a congress to choose the final form of such a project. For a time it appeared as if Dr. Zamenhof's hopes for authoritative action of this kind were to be realized. He submitted his project, and the secretary of the Society published a translation under the title of "An Attempt Toward an International Language," by Dr. Esperanto, Warsaw, Russia." However, the proposed congress never materialized.

The demand for improvement grew with the development of the propaganda, and in 1894 Dr. Zemenhof published, through the official gazette, "La Esperantiste," a new grammar based upon the proposed changes, which was submitted to the then active Esperantists and rejected by a majority vote. This attitude was further emphasized by a "Declaration" adopted at the first international congress, since which time the Esperantists have consistently and resolutely refused to consider, either through their journals or in their congresses, efforts to introduce changes other than in accordance with the Esperanto "Fundamento," preferring to await and work for governmental recognition and authority.

One of the most interesting features of the Esperanto movement has been the international congresses, of which twelve have been held down to the present time. The number of delegates has varied from 600 at the first to from 1,200 to 1,700 at others; and to each congress many governments have sent official representatives. The first, and in many respects the most important congress, was held at Boulogne-sur-Mer, France, in August, 1905, and resulted in the formation of an organization for the control of all matters pertaining to the language and its propaganda. From this time progress was rapid and the propaganda spread into all quarters of the

world. The tenth congress was to have been held in Paris, August 2-10, 1914, but on the opening day when delegates from all parts of the world were congregating in the city or on their way there, war was declared and the congress was obliged to adjourn at the close of its first day's session. The following year, 1915, the eleventh congress was held in San Francisco, August 22-29, in connection with the Pan American Exposition. No further congresses were held until after the war, and the vitality of the Esperanto movement is evidenced from the fact that in August, 1920, at the twelfth congress, held at The Hague (August 8-14), 400 delegates were present representing 23 nations. At this congress measures were taken to reorganize the Esperanto movement, and Prague was selected as the meeting place for the next congress, the thirteenth, July 31-August 6, 1921.

It is impossible to give any reliable statistics regarding the number of adherents, but some idea of the growth of the movement may be gained from the fact that the number of Esperanto groups or societies as given in their official handbook had grown from 42 in 1902 to 1,575 in 1913. In 1905 there were 36 journals published, while in 1912 this had risen to 94 representing 31 countries, among them 26 devoted to special subjects, literature 9, national propaganda 59. During the war the number fell off very considerably, but since the armistice the list has grown rapidly and at last reports about 70 were being published.

Out of the meetings of a number of international congresses and learned societies held during the Paris Exposition in 1900, *i.e.*, five years before the first international congress of Esperanto, there was organized, the "Delegation for the Choice of an International Auxiliary Language." The official program and regulations for carrying out the plan were set forth in a "Declaration," which provided that the "choice of an auxiliary language belongs in the first instance to the International Association of Academies," and that in case of failure of the Association to act it should be the duty of the Delegation to appoint a Committee to undertake the task, and, further, that it should be the duty of this Committee "to create a Society for propaganda, to spread the use of the language which is chosen."

The meetings of the International Association of Academies were held triennially, but the matter was not officially laid before the Association until its third meeting, held at Vienna at the end of May, 1907. Up to this time the Delegation had received the adherence of about 300 societies and organizations of business men, tourists, etc., and the approval of over 1,200 university professors.

The Association decided that the question did not fall within its competence, "because history itself would eventually select the best universal language." The immediate result of this decision was the appointment of a "Committee of the Delegation," as provided in the Declaration. This Committee consisted of twelve members among whom were Professors Louis Couturat and Leopold Leau, authors of "L'Histoire de la Languages Internationales," and Professors Otto Jespersen and W. Ostwald.

The Committee met in Paris October 15-24, 1907, and after several sittings decided:

"That the Committee adopt in principle Esperanto on account of its relative superiority and the numerous and varied applications that have been made of it, subject to its being modified in accordance with the project IDO and the Secretaries' Report, and in trying to agree with the (Esperantist's) Language Committee." The Committee then declared "that the theoretical discussions are closed," and elected a permanent Commission "whose first task will be to study and fix the details of the language adopted."

Efforts were made to gain the approval and coöperation of the Esperanto Language Committee, but the matter became involved in controversy over the ultimate authority of the different bodies concerned and finally resulted in a complete rupture between the Esperantists and Idists.

Failing to obtain the recognition of the Esperantists the Permanent Commission turned its attention to the discussion and solution of questions left unsettled by the Committee of the Delegation and to the publishing of text-books and dictionaries of the language in accordance with the decisions and indications of the Delegation. The first text-books and dictionaries were published in the spring of 1908, and in March of that year was begun the publication of a monthly journal called "*Progreso*, the Official Organ of the Delegation for the Adoption of an International Auxiliary Language and its Committee; consecrated to the propagation, liberal discussion and constant improvement of the International Language."

In July, 1910, the Delegation (having achieved its object) was regularly dissolved, after having founded, in accordance with one of the articles of its program, The Union for the International Language, whose mission was to develop and to propagate the "International Language of the Delegation." The headquarters of the Union are at Zurich, and its affairs are directed by a "Direktanta Komitato" and an "Akademio."

From the time of the publishing of the first text-books and dictionaries the propaganda became very active, attracting in several countries numbers of former Esperantists, among whom were many counted as active propagandists. By the end of 1910 the movement had acquired considerable momentum and it appeared for a time as if it might equal or even surpass the Esperanto movement, but the constant introduction by the "Akademio" of changes and improvements from about this time up to 1913, making it impossible in many countries to obtain up-to-date instruction books and dictionaries, served to seriously check the propaganda. To avoid confusion so far as possible from the policy of progressive changes and improvements, "periods of stability" were adopted, with the intention that changes discussed and adopted by the Academy during each period should become official and binding only after the termination of such period. The first period closed on July 1, 1913, and the second period is to extend for at least ten years.

It is claimed (official journal *Progreso*) that at the outbreak of the war there were about 200 groups of national propaganda societies in all parts of the world, seventeen reviews or magazines published in various countries, and that adaptations had been made to fifteen languages. The first Ido congress was appointed to be held at Luxemburg, September 6, 7 and 8, 1914, but the war prevented the meeting. Efforts are now being made to organize a congress to be held at Vienna this year. Two text-books in English[2] have been published recently which include all changes and improvements made by the Academy up to the close of the first "period of stability," and an English-Ido dictionary is being prepared.

The aim of both the Idists and Esperantists is eventually to secure governmental recognition of an international auxiliary language, including its introduction into the public schools and its use in official international business. Their points of view and methods of attack may be summed up briefly by saying that the Esperantists believe that Esperanto in the form it has stood unchanged for thirty years, is good enough at least as a sort of working hypothesis until substantial governmental recognition for the international language problem in general can be secured, and that the most important work at present is to keep on steadily extending the everyday use of the language and educating the public to its utility and relative stability, carefully avoiding controversial details of ultimate possible improvements as apt to distract attention from the main issue of general use and shake confidence in the permanency of the movement as a whole.

The Idists, on the other hand, have laid special stress upon perfecting the linguistic details of the project as early in the development as possible and have consequently striven to

[2]"IDO," an "Exhaustive Text-book of the International Language of the Delegation, and Fundamentals of an Artificial International Language," by Dr. Max Talmey, New York; and "Complete Manual of the Auxiliary Language IDO," by the British Idistic Society, London.

keep up this process of change and improvement progressively along side of general propaganda similar to but more conservative than that of the Esperantists, even at the risk of shaking public confidence in the stability of the proposed language.

The war necessitated vitally important and extraordinarily intimate relations between many nations of different speech, and, together with the work of solving the many new and difficult problems incident to the period of readjustment, has aroused the world as never before to the consideration of all matters bearing upon international intercourse and has especially emphasized the irritation and inconvenience arising from the confusion of tongues. This has led to a renewal of interest in the solution of the international language problem and to the conviction that steps should be taken through non-partisan sources to bring about a thorough investigation and study of the whole subject, with a view to the eventual selection or approval of some one project. The continued spectacle of rival systems, each with its own body of adherents and each striving through narrow partisan methods to gain official governmental or other authoritative recognition, is very far from edifying and has at times undoubtedly tended to discourage the faith of the world at large in the outcome of the problem; for unless there can be essential agreement upon some one project, international language becomes merely a linguistic hobby and therefore of no use to civilization. On the other hand, the lasting benefit of a decision based upon the testimony of partisans of this or that project is doubtful. Decision should be made only after thorough and impartial investigation and study of the general problem and a comparison of the various projects.

The period of partisan controversy shows signs of coming to a close and to be replaced by a period in which the individual adherents will more and more lay aside old prejudices and turn the whole of their combined efforts into constructive channels, recognizing that each project has in the past contributed certain elements of discussion necessary to the final solution of the problem, independent of which side of the argument they have taken. An interesting and very ingenious attempt at combining selected elements from both Esperanto and Ido has lately been put forward by Dr. R. de Saussure,[3] under the title of "Esperantida." No matter to just what extent this or that particular side finally prevails, the discussion is highly important for securing public confidence that the fundamental questions have been thoroughly tried out and the possibility of overlooking important aspects thus eliminated so far as possible before any project receives final official approval.

It was in the belief that the time was ripe for taking steps to win the attention and consideration of responsible academic agencies to a thorough study of the problem in all its aspects, that the subject was brought to the attention of the International Research Council, at its meeting in Brussels, July 18-28, 1919. The following resolutions were unanimously adopted:

RESOLVED: (a) That the International Research Council appoint a Committee to investigate and report to it the present status and possible outlook of the general problem of an international auxiliary language.

(b) That the Committee be authorized to coöperate in its studies with other organizations engaged in the same work, *provided*, that nothing in these resolutions shall be interpreted as giving the Committee any authority to commit the Council to approval of any particular project."

Dr. Frederick G. Cottrell was appointed Chairman of the Committee, which is headquartered at the offices of the National Research Council, 1701 Massachusetts Avenue, Washington, D. C.

It is not the intention that this central Committee shall necessarily of itself enter upon an extensive investigation and study of the international language problem, but rather, in the first instance at least, to stimulate interest and centralize effort in the study of the question by and through responsible and competent academic organizations and educational institutions in this and other countries and then to act as a clearing-house for the exchange of information and plans between them; so the first work of the committee has been confined to efforts to awaken interest and to secure the organization of committees and working groups in certain learned societies and universities, and already a number of such committees and study groups have either been appointed or are authorized. The Committee will also help the individual university groups to build up their library equipment.

[3]8 Marianstrasse, Bern, Switzerland.

The first national response to the appointment of the International Committee was by the British Association for the Advancement of Science, at its Bournemouth meeting, in September, 1919, in the appointment from its "Section on Educational Science," of a committee "To Study the Practicability of an International Language." Mr. W. B. Hardy, Secretary of the Royal Society, was appointed Chairman, and as such becomes also the British representative on the International Committee; Dr. E. H. Tripp, Secretary of Section L (Education) of the British Association for the Advancement of Science, was appointed Secretary. This British Committee has been active during the past year, and at the annual meeting of the British Association at Cardiff, in August, 1920, an interim report was submitted covering its preliminary work and the Committee was continued for the coming year. The British Classical Association has also appointed a special committee to cooperate.

In this country the American Association for the Advancement of Science has authorized the appointment of a committee; the National Research Council has authorized the appointment of a delegate to a joint committee between the National Academy of Science, the American Association for the Advancement of Science and the National Research Council; and the American Council on Education (including The Modern Language Association of America), The American Philological Association and the American Council of Learned Societies, (The American representative of the International Union of Academies) and the American Classical League have already authorized or appointed committees on the subject.

The purpose of establishing these various committees at the very start is to insure that the approach to the subject shall be taken in an adequately broad and conservative manner and that no important aspect of the problem shall be overlooked.

The aim of the Committee on International Auxiliary Language is to gradually build up a large and competent group of investigators having both theoretical and practical knowledge of the problem, and so form a really adequate panel from which members for a central international commission, preferably under the League of Nations or whatever agency finally functions in that capacity, may ultimately be drawn to deal constructively and so far as possible authoritatively with the subject and insure competent pronouncement on details and the greatest possible stability of the final project for practical purposes of international communication. "Internationalization of thought is the motto of the twentieth century, the device on the banner of progress. Science, the Super-Nation of the world, must lead the way in this as in all other things. Amidst the clangor and the clamor of political and commercial strife, the quiet empire of knowledge grows, noiseless and unseen. Let all those who believe that this peaceful empire is destined to become the controlling force of the world assist in the attunement of its common language."[4]

[4]F. G. Donan, in his preface to "International Language and Science."

SIZE OF THE POSITIVE ELECTRON

THE smallest particle of ponderable matter is the atom which has a diameter of a one hundred millionth part of a centimeter. Infinitesimal as this is it is a hundred million times larger than the positive electron whose diameter is 10^{-16} cent.

Notes on Science in America

Abstracts of Current Literature

Prepared by Edward G. Spaulding, Ph.D., L.L.D., Professor of Philosophy, Princeton University

THE RELATION OF MENDELISM AND THE MUTATION THEORY TO NATURAL SELECTION

THE main factors which Darwin presented as resulting, in their actions and reactions, in natural selection are three in number:

First. *Heredity*, by which the progeny tend to resemble their parents more than they do other individuals of the same species.

Second. *Individual variation*, by which the progeny tend to depart from the parental type and sometimes from the specific type.

Third. *Geometrical ratio of increase*, by which each species tends to reproduce more individuals than can survive.

Each of these factors is practically axiomatic, so little is it open to argument. No one doubts the *fact* of heredity, whether pangenesis, Weismannism or Mendelism be the correct expression of the mechanism involved. No one doubts the *fact* of variation; whether it is the "individual variation" of Darwin, the "fluctuating variety" or the "mutation" of De Vries. No one doubts the *fact* of geometrical ratio increase.

A moment's reflection will show that geometrical ratio of increase is a *quantitative* factor, giving an abundance of individuals from which to select; that individual variation is a *qualitative* factor, giving the differences which make a selection possible; and that heredity is a *conservative* factor, holding fast those characters which better fit the organism to its environment.

Now there is no possible outcome of the necessary action and interactions of these three factors that would not be a *selection* of some sort.

Three outstanding theories have been advanced since the publication of the "Origin," each involving an advance in our knowledge of the mechanism of heredity on the one hand and of the origin of variations on the other. Mendel's theory regarding the purity of the gametes, their segregation in the sex cells, and the whole complex Mendelian mechanism so admirably described by Morgan; all of these, fascinating and important as they are, deal with the *mechanism* rather than the *fact* of heredity. But it is the theory of mutation that has furnished most of the ammunition for the opponents of natural selection; and this in spite of the fact that De Vries, the originator of the mutation theory, expresses himself with great clarity as follows:

"My work claims to be in full accord with the principles laid down by Darwin and to give a thorough and sharp analysis to some of the ideas of variability, inheritance, selection and mutation which were necessarily vague in his time."

In 1904, when these words were published, there did seem to be a sharp distinction between the ideas of Darwin and those of De Vries. Darwin believed that individual, usually small, variations furnished the material on which selection acts; while De Vries thought that mutants, usually large variations, furnished the material. Both, however, believed thoroughly that natural selection was a *vera causa* of evolution.

But things have changed greatly since 1904. The work of Morgan, Castle, Jennings and a host of others has shown that many mutations are so small, from a phenotypic standpoint, that they are quantitatively no greater than the individual variations of Darwin; and that they are heritable in the Mendelian way.

Castle produced a perfectly graded series of hooded rats which exhibits almost ideally the steps by which a new form might be produced by natural selection. And Jennings says:

"Sufficiently thorough study shows that minute heritable variations—so minute as to represent practically continuous gradations—occur in many organisms: some reproducing from a single parent, others by biparental reproduction. . . . It is *not* established that heritable changes may be sudden large steps; while these may occur, minute heritable changes are more frequent. . . . Evolution according to the typical Darwinian scheme, through the occurrence of many small variations and their guidance by natural selection, appears more consistent with the data than does any other theory."

Many believers in mutation have been needlessly befuddled by the diverse meanings of "variations" as used by Darwin and De Vries. Darwin included in his "individual variations" both the "fluctuating varieties" and the "mutations" of De Vries. Phenotypically they cannot even now be distinguished. De Vries himself candidly admits that this was Darwin's attitude, thus proving himself more clear-sighted than many of his followers.

Just as Mendelism has to do with the *mechanism* and not the *fact* of heredity, so the mutation theory deals with the *nature* and not the *fact* of variations. Neither, in my opinion, has any implication that is antagonistic to the theory of natural selection.

In conclusion it seems that we are justified in maintaining that Mendelism and the mutation theory, while forming the basis of the most brilliant and important advances in biological knowledge of the last half century, have neither weakened nor supplanted the Darwinian conception of the "Origin of species by means of Natural Selection."—Abstract from an article in *Science*, February 11, 1921, by L. L. Nutting.

THE COMPRESSIBILITY OF DIAMOND

MANY of the properties of that remarkable form of carbon, the diamond, are known, but its compressibility has never been measured. The commercial value of a quantity of diamonds sufficient for such a determination is so great that the opportunity for making the determination would seldom present itself. It is not necessary for this purpose, however, that the material be in one piece or even in large fragments although, contrary to what is commonly believed, no apprehension need be felt in subjecting diamonds or any other homogeneous material to the enormous pressures required.

The method used has been described in a former publication from this Laboratory. Briefly, it is as follows: The material to be investigated is surrounded by kerosene and placed in a cylindrical, heavy-walled, steel bomb, one end of which is closed while in the other end is fitted a piston with a suitable packing. Pressure is applied by forcing the piston into the bomb by means of a powerful hydraulic press. In order to determine the compressibility it is necessary to measure the pressure and the decrease in volume. The pressure is measured by means of a small coil of "therlo" wire the resistance of which changes with pressure according to a known relation; and the volume-decrease is determined by the movement of the piston, which is measured with a dial micrometer. Pressures were read to 1 megabar (1 megabar $=$ 0.987 atmosphere) and piston displacements to 0.001 mm. As a means of correcting for the compressibility of the kerosene, an exactly similar series of measurements is carried out with some other substance of known compressibility.

The diamonds were placed in a thin-walled steel capsule, and the comparison body was a Bessemer steel cylinder the volume of which was equal to the volume of the diamonds plus the volume of metal in the capsule. In order to remove any air

bubbles, the material having been placed in the capsule, was covered with kerosene and the whole evacuated.

With the apparatus used the most accurate measurements are obtained in the range from 4,000 to 10,000 megabars. Accordingly, it seemed best to make several series of readings within this range of pressure. Readings were taken at 4,000, 6,000, 8,000 and 10,000 megabars. Three separate runs were made with the diamond and two with the steel, but the first series with the diamond was subject to slight irregularities due to trouble with the electrical connections and was therefore neglected in the final calculations. The method for calculating the results and for making the various corrections is described in detail in the former paper already referred to.

The results show that the compressibility of diamond is remarkably low; indeed, of all substances whose elastic behavior is known, diamond is by far the most incompressible. Its nearest competitor, tungsten, is nearly twice as compressible (0.27×10^{-6}), and the majority of solids decrease their volume more than ten times as much for a given increment of pressure. If a diamond were buried 100 miles below the surface of the earth the pressure due to the superincumbent rock—a higher pressure than has ever been attained in the laboratory—would decrease the volume only about three-fourths of one per cent.

This is the lowest compressibility of any known substance.—Abstract of article by L. H. Adams of the Geophysical Laboratory, Carnegie Institution of Washington, in the Journal of the Washington Academy of Sciences for February 4, 1921.

PHOTO-ELECTRIC CURRENTS IN THE EYE

In the January number of *Physiological Reviews*, a new publication edited for the American Physiological Society, Mr. Charles Sheard presents an important article on the subject of photo-electric currents in the eye.

The process by which the ether disturbance causes a visual impulse may be ascribed to (*a*) chemical action, (*b*) molecular strain and (*c*) electrical action.

According to the *chemical* theory it is presumed that certain visual substances (or possibly substance) in the retina are affected by light and that vision originates from metabolic changes produced in these visual substances. It is supposed that the metabolic changes consist of two phases; the upward, constructive or anabolic phase, and the downward, destructive or katabolic change. These anabolic and katabolic changes in various visual substances are supposed to produce the variations of sensation of light and color. This theory is complex. Numerous objections have been urged against its acceptance; for it is difficult, for instance, to see how this very rapid visual process can be due to a comparatively slow chemical action consisting of the destructive breaking-down of the substance followed by its renovation. Support was at first furnished the chemical theory, as it has ordinarily been presented, by the bleaching action of light on the visual purple present in the retina, but it has been discovered that the presence or absence of visual purple is not essential to vision and that its presence is of only secondary importance. For it is well known that the visual purple is lacking in the *fovea centralis* and it is also found to be completely absent from the retinas of many animals possessing keen sight.

The *mechanical* theory depends, in large measure, upon the theory of resonance in connection with chemical action. It is readily conceivable that a ray of light can cause a chemical decomposition of a substance in which the rhythmic excursions of an atom or atoms from, or round about, the center of attraction in a molecule are in exact tune with the waves of light falling on such atoms. The excursions may be so increased in extent by the rhythmic energy supplied by the light waves that the atoms will leave the parent molecules and produce new molecules. It is not as easy to see why the rhythmic excursions of atoms in the same molecule are also increased to the point of molecular rupture when the wave-motion of the impinging rays is not in tune or nearly so. But some photographic and mechanical examples help us out. For if a sensitive salt, such as silver chloride, is exposed to the action of the spectrum, we can plot a curve showing the sensitiveness of this particular salt to the different spectral rays. Such a plotted curve shows a rise in sensitiveness to a maximum followed by a decline; the maximum of such curve shows the place in the spectrum where the vibrations composing the beam of light are in tune with the vibrations of the chlorine atom in silver chloride, for example, the chlorine being that part of the molecule which is swung away and annexed to some other adjacent molecule.

The essential points in the mechanical theory of retinal stimulation as consisting of resonance effects coupled with chemical action fit in with many of the physical phenomena known as *photo-electric* actions. This term includes phenomena due to the action of light in liberating negative electrons from various metallic substances. It is known, for example, that there is a considerable influence of the wave-length of frequency of the light upon the number of electrons emitted and that curves plotted between frequency and rates of "leak" of negative electricity from metals such as sodium, potassium and rubidium show maximum or resonance effects. Likewise, salts which undergo decomposition in the light, such as silver chloride, are strongly photo-electric. We are, therefore, presumably dealing under the tenets presented to us in this theory with the expulsion of electrons due to resonance; the electrons are set in resonant vibration by the incident light and acquire sufficient velocity to enable them to escape from the atom. In the case of photo-electric effects from metals it has been possible to identify the valency electrons which play the part of chemical bonds with the photo-electric electrons which can be liberated by the action of light. From this point of view a photo-electric change and a photo-chemical change may be regarded as of the same character, consisting essentially in the displacement or separation of an electron through the absorption of energy from a light wave. We may thus have two kinds of photo-chemical action. In a primary or direct action the same valency electron which has absorbed the energy is itself released from its connection with a strange atom, while in a secondary or indirect action the electron which has absorbed the energy causes by collision the separation of an electron from an atom.

These various fundamental concepts are presented for the reason that there are various data afforded by the author's own experimental results which are in accord with certain of the principles underlying both the chemical and mechanical theories.

Mr. Sheard here describes in detail his general experimental procedure, makes a critical survey of the data obtained by other investigators, and concludes:

1. That positive retinal currents are manifested and positive electro-motive forces established when an eye is illuminated by light.

2. That the source of these electrical changes lies in the retinal structure or in the posterior part of the eyeball.

3. That luminous stimuli of different wave-lengths—from red to violet—give initially positive retinal currents. Hence all responses are of the same general type, and act in accordance with their luminosity.

4. That the stimulus-response relation is such that the curve representing it is concave to the axis representing the stimulus.

5. That fatigue is less pronounced in the case of the retina than in that of muscle.

6. That the time-relations of the responses or periods of latency after application of stimuli are of the order of 2/10 to ½ a second.

7. That there is a characteristic response to darkness as well as to light stimulation.

8. That the range of light vibrations under which animals' (frogs quite largely) eyeballs give definite photo-electric re-

sponses corresponds very closely to the range of vision of our own color sensations.

9. That photo-electric effects with sensitive cells may be obtained which are wholly analogous to phenomena obtained with eyeballs.

10. That experimental results point to the localization of two photo-electrical substances in the posterior half of the eyeball or that the retina is the seat of a double electrical movement which may consist of duplex changes in one substance or of two changes in two different components.

Research Work of the United States Bureau of Standards

Notes Specially Prepared for the SCIENTIFIC AMERICAN MONTHLY

FIRE TESTS OF BUILDING COLUMNS

A detailed report of fire tests and fire-and-water tests on over 100 building columns has recently come from press. This report contains results of an investigation which has been conducted jointly during the past six years by the Bureau of Standards, the National Board of Fire Underwriters, and the Associated Factory Mutual Fire Insurance Companies. An edition of 5,000 copies of this report has now been published by the two last-named coöperating agencies and copies are available at what is practically the cost of publication. The report contains 389 pages and numerous illustrations, curves, and tables. A small edition of the same report will appear in the course of the next few months as a Bureau technologic paper.

Copies of the complete edition, above referred to, may be obtained for $2.00 per copy for paper cover and $2.50 for cloth cover from the Underwriters Laboratories, 207 E. Ohio Street, Chicago, Ill., or from the Associated Factory Mutual Fire Insurance Companies, 31 Milk Street, Boston, Mass.

RADIUM

It is probably not very generally known that practically all of the radium bought and sold in the United States passes through the hands of the Bureau of Standards. Any one in buying a radioactive material naturally wishes to know whether the substance contains genuine radium, and the determination of this is one of the important functions of the Bureau of Standards. It is practically impossible to sell articles depending on radium for their value without first obtaining the certificate of the Bureau. It has seemed worth while to issue a few facts concerning this subject for the benefit of those who may not be very well acquainted with radium testing as at present carried on.

Radium is a chemical element, one of the heaviest and most valuable known, being worth 200,000 times its weight in gold. It was discovered in 1898 by Madame Curie, a French scientist. It is found in nature as an ore, as a constituent of pitchblende in Europe, and of carnotite (found in Colorado and Utah) in this country.

Carnotite is an ore combining uranium and vanadium and either potassium or calcium. It is a low grade ore, in reality a sandstone cemented by the carnotite material. Five hundred tons of this ore produce one gram of radium, requiring 500 tons of chemicals and 1,000 tons of coal for its recovery. This amounts to between two and three parts of radium in a trillion of ore. The present market price is about $110 per milligram, or three million one hundred and twenty thousand dollars per ounce avoirdupois.

Radium is used to a small extent in radium-luminous paints, but chiefly in the treatment of cancer and other abnormal growths, for which purpose a sulphate, chloride or bromide of radium is used, and this is usually kept hermetically sealed in a metal needle or glass tube. The therapeutic virtue of radium lies in the power of its radiation to destroy tissue combined with the fact that normal tissue is more resistant to its destructive effects than abnormal tissue.

A radium specimen is measured by comparing it with a government standard of known size, the relative amounts of radium in the two being proportional to the rates at which they discharge an electroscope placed at a fixed distance, each acting alone. This method of measuring radium with its attendant necessary corrections requires a high degree of technical skill, and is not generally understood by the public. On account of this, as already mentioned, over 90 per cent of all radium recovered and sold in this country is sent to the National Bureau of Standards to be measured and certified, because after going through the tremendously expensive process of reducing the ores and recovering the radium it is practically impossible to market it without government measurement, and the government certificate.

Within the last six months, the radioactivity section of the Bureau of Standards has measured and certified over two million dollars' worth of radium for shipment, not only to nearly all parts of the United States. but to Canada, England, Holland, Denmark, France, Italy, Japan, India, Australia, Argentina, Brazil, Peru, and Porto Rico.

CIRCULAR ON THE PHYSICAL PROPERTIES OF MATERIALS

During the past few years, the Bureau of Standards has received numerous requests for information regarding the physical properties of materials, principally ferrous and non-ferrous metals and alloys. Some time ago, the compilation of most of the available data on this subject was undertaken. The tables which were compiled as a result of this work were issued to a limited number of government establishments in mimeographed form.

As they seemed to fill a very real need, it was deemed advisable to issue them in the form of a Bureau publication, and Circular No. 101 has been the outcome of this work. The circular aims to present in readily accessible form the best available data on the strength and related properties of materials. Among those treated are iron, carbon steel, alloy steels, wire and wire rope, semi-steel, aluminum, copper, miscellaneous metals and other alloys, rope, rubber, leather, and wood. The tensile strength, proportional limit, percentage elongation in 2 inches, percentage reduction of area, Brinell and scleroscope hardness corresponding to a certain composition, density, and method of preparation are shown in most cases for the metals and alloys In addition, figures are given in many instances for the compressive and shearing strengths, moduli of rupture, and Erichsen values. The circular also includes definitions of the properties treated and references to sources.

TESTING OF PAPER

Many requests are received by the Bureau for information in regard to the testing of papers and apparently interest in this subject is steadily increasing. For this reason it has been deemed advisable to issue a circular devoted entirely to paper testing. This is Circular No. 107 of the Bureau of Standards and takes up methods of testing paper and the

apparatus employed in the paper laboratories for routine work.

In the introduction, the size and importance of the paper industry is described and the various fibrous raw materials which go into paper manufacture are considered. During recent years a great deal of attention has been centered on the possibility of using grasses and crop plants for the making of paper. The Bureau has had considerable experience along this line and it is pointed out in the circular that the making of paper from such sources on a commercial scale is largely dependent on the cost of production and the availability of the raw materials. A rough classification is made of paper and a short definition stating that "paper is a matted or felted structure of fibrous material formed into a relatively thin sheet" is also given. The value of paper testing is brought out and it is emphasized that various testing methods must be used for papers for different uses. The physical qualities of paper are affected by changes in temperature and humidity and it has been found necessary to construct a special room in which constant conditions of 70° F. temperature and 65 per cent relative humidity may be maintained. This insures that all tests conducted will be on the same basis.

Under chemical testing are given the methods of determining the percentage of ash in paper and the amount of sizing. Two methods are given for the quantitative determination of rosin in paper, and qualitative tests for the various kinds of loading materials are outlined. Qualitative tests for various sizing materials are also given. The microscopical examination of paper and the estimation of the fibers from which it is made is now an important matter and the procedure of the Bureau is given in detail.

Finally, a working bibliography of useful books, periodicals, and government publications on this subject is included. Recommendations are made as to the size of sample which should be submitted for test and the fee schedule is given. It is important that proper methods be used in the sampling of paper and instructions are included as to how this should be done.

COLORED WALL PLASTER

Gypsum wood fiber plaster is a commercial article made of calcined gypsum, wood fiber, and other ingredients. This wood fiber can be dyed with aniline dyes to produce any desired color, the dyes being fast to light. By the use of dyed wood fiber a colored gypsum plaster can be made. After this has been applied to the wall and allowed to set, the surface may be scrubbed with soap and water thereby exposing the colored fiber. Some very beautiful effects may be produced not only because of the great variety of colors available but also by using fibers of different sizes, by employing different proportions of fiber and by various surface treatments. Since both the colors and texture can be controlled, an artistic effect is insured for the finished wall. This wall is essentially a plaster wall and should be treated accordingly. It can, however, be scrubbed with soap and water whenever it becomes dirty or when the colors become dull. Technologic Paper No. 181 on this subject has been issued by the Bureau.

SAND-LIME BRICK

This is a building brick made of sand and lime and was first produced in the United States in 1901. By the action of steam under pressure, the lime is caused to combine with some of the sand forming a hydrated calcium silicate. This material acts as a bonding agent to hold the rest of the sand together. Most sand-lime bricks will compare favorably with "first common" clay bricks. They are characterized by their straight edges, parallel faces, and nearly white color. Their continued use in northern climates has established their durability under weather conditions but sand-lime brick is not a refractory material. The industry maintains a national association with which the Bureau coöperates in research work. Bureau of Standards Technologic Paper No. 85 contains detailed descriptions of the method of manufacture, while Circular No. 109 is devoted to description and specification of the brick itself. A good sand-lime brick for general purposes should have an absorption of not over 20 per cent, an average compressive strength of not less than 2,000 pounds per square inch and an average modulus of rupture of not less than 450 pounds per square inch.

CORROSION OF SOFT METALS

The commercial soft metals include aluminum, tin, zinc, and lead. It has been shown previously—Bureau of Standards Scientific Paper No. 377—that a type of deterioration designated as "intercrystalline brittleness" may occur in lead under certain conditions whereby the metal crumbles to a coarse crystalline powder. The individual grains of this powder retain all the intrinsic properties of lead but the bond between the grains has been destroyed.

During the past year a series of corrosion tests has been carried on to demonstrate to what extent such deterioration may occur in other soft metals. The intercrystalline brittleness appears to be largely dependent upon the purity of the metal, and in the pure materials used in the test very slight evidence of such deterioration was obtained. A series of stress corrosion tests has been conducted to supplement Scientific Paper No. 377 and it has been shown that the simultaneous application of tensional stress to a specimen while corrosion is in progress is a powerful adjunct to deterioration by "intercrystalline brittleness." This is of practical importance, inasmuch as lead—because of its great weight—is often subjected to very considerable stress while in service. Thus the tendency to corrode and become embrittled is accentuated.

TABLES OF THE PROPERTIES OF AMMONIA

The very accurate measurements which the Bureau has been making during the past few years on the thermodynamic properties of ammonia are only of use to engineers when tabulated in the form ordinarily employed for such data. The work completed is sufficient for the preparation of the table of the properties of ammonia liquid and vapor under saturation conditions, and such a table has been issued in mimeographed form. The values therein fortunately do not differ by more than a few per cent from those in tables now in general use. The measurements of the properties of superheated ammonia are now under way but it will be some time before the results will be available for completing the table.

MOLLIER DIAGRAM FOR THERMAL PROPERTIES

The Mollier diagram is a chart used by engineers to represent graphically thermal properties of a substance thus serving as a convenient substitute for the usual tables of properties. As ordinarily drawn, heat content and entropy are used as the principal coördinates of the diagram. However, this diagram is not well suited for representing the properties of ammonia. An examination of the various modes in which the diagram might be drawn showed that the choice of heat content and a suitable function of the pressure produced a much more usable diagram for ammonia. A brief account of this work will be published in the Journal of the Society of Refrigerating Engineers.

CONSTRUCTION OF ELECTRIC RESISTANCE THERMOMETERS

The experience of the Bureau in the construction of resistance thermometers may be useful to others. Therefore, a description of the resistance thermometers now in use and of the methods of construction employed has been prepared as one of the Bureau's scientific papers. A short note on the same subject is to appear in the Journal of the American Chemical Society.

Progress in the Field of Applied Chemistry

Notes Culled from Current Technical Literature

By H. E. Howe, Member of American Chemical Society

HELIUM

THE address of Dr. R. B. Moore before the Franklin Institute has now appeared as a reprint and may be unqualifiedly recommended to any interested in this story. The account of helium is one of the romances of science and its discovery represents one of the best examples of work in pure science which ultimately has great commercial application. The lecture in question gives the history of the discovery of radium, gives data as to its occurrence and discusses its properties at length. It then takes up in detail the initiation of the helium project, that is, the separation of this gas from certain natural gases in order that it might be produced in sufficient quantities for the use of dirigibles. The plants constructed for this purpose are described with the aid of illustrations.

The origin of helium in natural gas is of great scientific interest. The helium in the air is ordinarily believed to be due to radioactive changes going on in the uranium and thorium minerals in the earth's crust but the origin of this gas in natural gas confined in the earth is more difficult to explain. Two thousand pounds of uranium metal together with all of its disintegrated products will give 110 cu. mm. of helium per annum. It is estimated that the total amount of helium which has been evolved by the gas wells in the Petrolia fields to the present time is more than sixty million cubic feet. The area of the field being not more than 8 or 10 square miles it is inconceivable that sixty million cubic feet of helium could be produced by radioactive changes in the earth's crust within this area. Another explanation rests upon the supposition that the helium included below the earth's crust was brought from the sun at the time the earth was thrown off but this does not explain its localized occurrence. Again if helium has such an origin then it should contain other gaseous elements known to exist in the sun and Dr. Moore has already done some work to determine possible new elements to be found in the gas.

The commercial storage of helium presents one of the most interesting problems. It has been suggested that concrete chambers might be built in mine drifts and that these chambers should be lined with sheet copper to prevent loss of gas through the concrete. With such equipment the cost of storage per annum might be as low as one-tenth to one-fifth of a cent per cubic foot.

"It has also been suggested that helium might be stored in some of the salt deposits of New York. In this State some of the rock salt deposits are 60 feet thick and covered with a fairly heavy overburden. By drilling into the salt, and flushing out with a stream of water, a circular cavity could be made in the salt with a long neck, such cavity being 40 or 50 feet in diameter. The chamber would be something like a bottle with a very long neck, and helium might be stored in such a chamber under pressure satisfactorily. A series of "bottles" could be placed close together in the same deposit. It is necessary, of course, to know whether helium does or does not diffuse through salt in order to apply such a scheme practically, and this diffusion work is now being done by the Bureau of Mines."

CLAY FOR PAPER

A SHORT time ago there was considerable anxiety among paper manufacturers because they had not found in America the types of clay preferred as fillers upon which the finish and printing cost of book paper largely depend. The Forest Products Laboratory in Technical Note 139 gives the following information concerning a new American clay found suitable for this purpose:

"A highly colloidal clay which exists in large deposits in the intermountain regions of the United States has been found by the U. S. Forest Products Laboratory to be valuable as a loading material for giving finish and printing qualities to book paper. When this clay is used in conjunction with English china clay, the retention of the English clay is materially increased, and the paper produced has a superior finish and appearance, and a more velvety feel. The admixture of this clay similarly improves the retention of other fillers, and is especially desirable with some which have a low retention.

"The ability of the new clay to remain in suspension may make feasible the installation in paper mills of a central mixing plant, from which the loading material can be piped a considerable distance to the beaters, without danger of settling or clogging of the pipe lines, and with the assurance that the concentration will remain uniform. The properties and use of the new loading material are more fully described in a report which may be obtained from the laboratory on request."

STAINLESS STEEL

Canadian Machinery discusses methods for making stainless steel which consists usually of an alloy of iron and chromium from 0.1 to 1 per cent of carbon and from 12 to 14 per cent of chromium.

"The metal is cast in the usual manner into ingot molds, and the ingots are forged or rolled into bars or sheets. The material can be forged fairly readily into various forms if heated to a bright orange temperature; and if after forging the metal is allowed to cool in air, it will be found to possess good cutting qualities.

"Quenching in water enhances the hardness to a considerable degree, especially if the steel contains more than 0.4 per cent carbon, but oil quenching gives the best results. This steel resists formation of scale during forging to a great extent, and is therefore adapted to high-temperature uses, such as engine valves, distilling apparatus, and so on. The steel is slowly attacked by dilute or strong sulphuric and hydrochloric acids, practically unaffected by nitric acid, and is unaffected by nearly all the fruit acids and strong vinegar."

THE PROCESS OF AGEING CLAY

IT has been known from time immemorial that certain types of clay must be aged to make them satisfactory and there has been considerable discussion as to the factors of ageing and what changes take place in the clay itself. H. Spurrier in the February *Journal of the American Ceramic Society* discusses the result of his research and concludes that the growth of filaments algæ with the consequent evolution of both carbon monoxide and carbon dioxide is responsible for the change of plasticity of clays. This algæ theory will explain all of the various effects found. For example, the evolution of the carbon dioxide is found to continue for more than thirty-four days after pugging the clay, and like the change of plasticity to proceed more rapidly at temperatures between 80 and 90° F. than when below 60° F. When water was replaced by non-aqueous liquids development of plasticity was entirely inhibited while if treated with dilute solution of hydrogen peroxide the growth of the algæ was stimulated as was the evolution of carbon monoxide and carbon dioxide and there was a pronounced increase in viscosity.

At the same time plasticity was studied from the chemical side and based upon testing of three clays it was determined that the ratio of amounts of aluminum oxide and silica dis-

solved by caustic potash decreased rapidly with diminishing plasticity and, therefore, might well be used as a quantitative measure of plasticity. Ordinary determinations of silica and aluminum entirely failed to indicate differences in this character of a clay. The practical part distinguishes between sticky and plastic clay by filling them and the method of determining the ratio of alkali silica to alkali aluminum would appear to accomplish the same purpose and make it possible to express results in figures. The article quoted gives details as to methods of procedure and details as to results obtained in the tests.

LIME IN THE UNITED STATES

The following figures which have been compiled by the National Lime Association indicate very forcefully the distribution of the uses of lime in the United States and convey a better appreciation of the importance of this common raw material:

	Per Cent	Tons	Price	Value
Building	28.5	913,714	$8.40	$7,675,197
Agriculture	12.2	391,134	8.40	3,285,525
Paper Mills	10.1	323,807	8.40	2,719,978
Refractories	9.7	318,896	12.80	4,097,819
Metallurgy	7.9	253,275	8.40	2,127,510
Alkali Works	4.53	145,031	5.30	768,590
Unspecified Chemical Uses	3.80	120,774	7.88	952,701
Dealers	3.50	112,210	8.40	942,564
Calcium Carbide	2.73	87,434	8.97	785,912
Water Purification & Softening	2.36	75,448	7.90	596,667
Tanneries	2.30	73,738	8.40	619,399
Acids	1.20	32,388	7.80	298,660
Bleaching Works	1.18	37,905	8.12	306,726
Sugar Factories	1.10	35,266	8.40	296,234
Glass Works	1.10	35,266	8.40	296,234
Soap	.93	29,599	6.83	202,028
Silica Brick	.83	26,517	6.90	182,659
Phenol	.78	25,002	7.86	196,463
Coke Oven By-products	.765	24,451	7.15	174,437
Explosives	.74	23,735	7.30	173,129
Wood Distillation	.43	13,986	8.70	121,678
Ammonia Works	.43	13,975	7.14	99,831
Cyaniding	.39	12,512	9.55	118,274
Gun, Cotton & Gelatine	.34	10,755	8.30	88,784
Sewage Purification & Neutralization of acid water	.30	9,514	7.23	68,668
Glue Manufacture	.28	8,822	8.94	78,599
*Undistributed	.24	7,790	7.29	56,621
Sand-lime Brick	.23	7,417	8.00	59,357
Disinfectants	.19	6,059	8.48	51,438
**Undistributed	.14	4,481	7.35	32,966
Lubricating Grease & Renovova of butter, etc.	.106	3,395	8.35	28,410
Gas Plant By-products	.074	2,371	8.15	19,309
Cotton Thread & Woolen Mills	.07	2,117	10.13	21,425
Nitrates & Glycerine	.064	2,059	6.23	12,486
Spraying	.06	1,813	9.23	16,706
Salt Refining	.056	1,791	7.48	13,388
Dehydration & Mfg. of Alcohol	.048	1,535	6.94	10,638
Kalsomine	.03	999	9.07	9,076
Polishing & Buffing Compounds	.01	384	11.50	4,424
Polish Salts	.005	176	8.01	1,409
Coal & Water Gas Purification	.0054	171	11.45	1,959
Flour Mills	.005	164	10.88	1,785
Pottery & Porcelain Mfg.	.005	129	9.40	1,213

*Calcium acetate, aluminum hydrate, borum products and precipitated calcium carbonate.

**Candles, corn products, dyes, rubber, medicines, varnish, graphite, gold and platinum refining, slag cement, print works, tobacco, copper, and file works, sheep dip, etc.

DIAMOND POWDER

Diamond powder in oil is generally used as an abrasive for cutting facets on diamonds and sharpening points where very hard abrasive is required and trial has shown nothing else to be so satisfactory. After a time the powder becomes dirty, the cutting points become covered and its efficiency is lowered. Some maintain that a part of this powder becomes converted into graphite during the polishing operation but Richard C. Berger writing in the February 2 number of *Chemical and Metallurgical Engineering* holds that no temperatures or pressures are reached in the polishing operation which would cause the conversion of crystalline diamond powder into graphite. The recovery of the diamond dust is, however, important and the following method of refining the waste is given:

METHOD OF REFINING WASTE

"Extract the oil present in the waste by shaking thoroughly the waste paste with acetic ether or benzene, and allow to settle, decanting the clear supernatant solution after the paste has settled, which will take anywhere from ten minutes to three hours. Repeat several times until the deposit is free of oil, which state can be seen when the solid particles settle readily. The oil must be completely removed, as even small amounts will cause considerable annoyance because of the disagreeable odors, generated during the acid treatments and difficulties in filtering the residue. If desired, the solvent used for the extraction of the oil can be recovered by distillation.

"Dry the paste which has been freed from oil on a steam table or in a hot air bath at a temperature not exceeding 130 deg. C. until it is free from solvent, and treat in an evaporating dish under a chemical hood with strong nitric acid. Heat over a free flame, adding nitric acid until there is no further action, but do not allow to go to dryness. Dilute with water, allow residue to settle, and decant the supernatant liquid. Repeat the washings and decantations until the deposit is clean. Dry the residue on a steam table or in a hot air bath at a temperature below 130 deg. C.

"Heat the dried powder in an evaporating dish with strong hydrochloric acid under a hood until no further action, but do not carry down to dryness. Dilute with water, allow residue to settle and decant the supernatant liquid. Repeat the dilution and decantation until the solid deposit is clean. Put in an evaporating dish and place on a steam table or in a hot air bath below 130 deg. C. until dry.

"Melt solid sodium hydroxide in a wrought iron crucible, Remove the flame and allow to cool from red heat to dark and while the mass is still molten add the dried residue, stirring with a platinum wire or iron rod. Place a cover on the crucible and heat gradually to dull red heat. Cool until the sodium hydroxide is solid and then leach out the crucible by placing it in water and heating until all the sodium hydroxide is dissolved. Wash the solid particles in an evaporating dish or in a beaker by repeated decantation with water until clean. Dry the deposit, which should be clean, bright and crystalline diamond powder.

"If there should be considerable black particles of amorphous carbon (graphite) present, these can be removed by adding the dried powder to a solution of specific gravity approximately 3.2, allowing the crystalline diamond particles to settle and pouring off the suspension of carbon particles."

LUBRICATION

A Committee on Lubricants and Lubrication was appointed by the British Department of Scientific and Industrial Research in 1917 and has made several progress reports. It has now published a final report in which in addition to several specialized papers there appear recommendations for future research on lubricants and lubrication. It is always helpful to those engaged in research to have stated clearly the work

which is most needed and the following summary therefore is quoted from the report in question:

"(1) To isolate and determine the nature of the hydrocarbons in mineral lubricating oils which especially promote the properties of viscosity and 'oiliness.'

"(2) To determine the classes of hydrocarbons desirable in lubricants required to work under high pressures and high temperatures, particularly as regards their relative stability under the conditions obtaining in internal combustion engines, steam engines and air-compressors.

"(3) To study the causes and means of preventing the formation of carbonaceous deposits from lubricating oils under the conditions named in (2), with special reference to the nature of the hydrocarbons, sulphur compounds and resinous constituents of such oils.

"(4) To study the causes of emulsification in circulating oiling and in splash systems, with special reference to (a) the influence of the sulphur compounds in mineral oils, and (b) the characteristics of oils with non-emulsifying properties.

"(5) To study the causes of oxidation in circulation oiling systems, also the causes of formation of oxidation products in bearings and on bright metal surfaces.

"(6) To determine the direction in which the processes of manufacture can be modified so as to lead to the production of lubricating oils of improved types.

"(7) To discover new methods of analysis which will enable the chemist when examining a lubricating oil in the laboratory, besides determining its viscosity, specific gravity, flash-point, etc., to determine the constituents of the oil and with the help of the knowledge gained under (1) to (5) to measure its ability to reduce friction and to meet the conditions of speed, load, temperature and atmosphere in which it is required to work. Much of this information can only be ascertained today by the costly method of trial.

"(8) To elaborate further methods of producing lubricants synthetically in order to meet special requirements. Dicresylcarbonate, for example, has been used as a lubricant. Reduced naphthenes, glycerides of naphthenic acids and cinnamenes have been prepared and shown to have lubricating value. It might be found possible to produce lubricants whose rate of change of viscosity is less and whose freezing point is lower, than is the case with existing lubricants.

"(9) To prepare in a pure state the esters met with in animal and vegetable lubricating oils and determine their relative lubricating values.

"(10) To investigate the claim made by Messrs. Wells & Southcombe, lately propounded in a paper read before the Society of Chemical Industry, that the free fatty acids present in commercial fixed oils are the active constituents which enable these oils to improve the lubricating value of mineral oils, and to investigate further whether the addition of such acids to mineral oils may in certain circumstances improve their lubricating value.

"(11) To investigate the colloidal nature of lubricating oils and its bearing upon lubricating problems.

"(12) To study the effect of ultra-violet light, sunlight and ozone upon lubricating oils.

"(13) To investigate the phenomena of dissimilar surfaces (oil and metal) in contact, especially in relation to the property of 'oiliness.'"

CLOTHS FOR MECHANICAL USES

James W. Cox, in the March number of *Mechanical Engineering*, discusses this question in an interesting manner and gives details concerning special uses of cloths for mechanical purposes. The tabulation of uses gives more than fifty items without pretending to be complete and the large industries in which cloth is used mechanically number more than thirty. Special mention is made of asbestos cloth which is an unusual product unlike any other cloth because of its heat and flame resisting qualities and, second, its neutrality to the action of acids and alkalis.

"For these two reasons it can be used in places where no other fabric can. The cloth is usually of heavy yarns and a plain weave, varying in closeness of mesh and thickness as the purpose requires.

"The great bulk of this cloth goes into steam packing. It is invaluable in this respect. In this are included gaskets and cut washers. The next largest amount goes into brake linings of all kinds, principally automobile. These may be entirely asbestos or wire warp with asbestos filling. Clutch facings come next in volume.

"Filter cloths of various degrees of openness and thickness are used, mostly in chemical plants. Wire backings may be used in this work. This type of filter cloth is also used in making such gases as oxygen and hydrogen, and in such plants where refuse or sewerage has to be disposed of. The cloth is easily cleaned by subjecting to fire.

"In the electrical industry asbestos cloth is used mostly in webbing or tape form in the manufacture of armatures, etc., and greatly in wire and cable manufacture. Tubing of this material is used also in cable manufacture and gives excellent protection.

"For fire doors, heat screens, and curtains a heavy fabric is used, either plain or with a wire warp. Theater curtains are of this type. Iron and steel mills use this cloth around furnaces, etc. Light asbestos cloth is used to wrap asbestos or magnesia packing, but in general heavy cotton sheeting or light duck is best for this purpose."

RESULTS OF TESTS WITH URANIUM STEELS

Iron Age prints the following abstract of results reported by E. Polushkin on uranium steels.

"The charge was composed of turnings and scrap and was melted down with lime. The first slag was removed and the steel refined under a second basic slag. The time of the heat was 4 hours 5 minutes. Additions in the furnace were ferromanganese and ferrosilicon and in the ladle carborundum and ferrouranium. The latter alloy was sometimes added in the furnace, sometimes in the ladle. When in the ladle from 70 to 75 per cent recovery of uranium was sometimes obtained, but generally the percentage obtained in the steel was irregular, often less than 50 per cent.

"Physical and other tests show no difference in results whether the alloy was added in the furnace or the ladle. As a rule two ingots were obtained, weighing about 120 pounds each.

"The results showed the steel to be full of defects such as blowholes and pipes. It is certain that these defects have their origin more in the method of steelmaking than that they are caused by the uranium.

"In steels with medium carbon, that is, 0.25 to 0.45 per cent, the uranium was found to raise the elastic limit and ultimate stress without affecting the ductility, or even raising it, also, Brinell tests show that uranium increases the hardness of steel. One heat with uranium and nickel gave very good results, showing ductility superior to ordinary nickel steel or chrome vanadium steel. The tests in certain other heats, however, did not show any favorable effects of the uranium."

READING LIST OF VITREOUS ENAMEL ON STEEL

In a list of various aids to research, bibliographies must be written near the top and whenever such lists of references appear those interested in the particular field or related subjcts are glad to be informed of it. The reading list, the title of which is given above, has been prepared by Clarence J. West and begins with the literature of the year 1907, inasmuch as the literature of the ceramic industry is very well covered up to the year 1906 by the Bibliography of the Clays and the Ceramic Arts compiled by John C. Branner. The abstracts reproduced in the bibliography have been abbreviated or omitted where the title indicates the scope of the article. A reference to the original abstracts noted in the bibliography will enable the investigator to eliminate those which may be considered unsuitable to his own purpose.

Progress in the Field of Electricity

Summaries and Excerpts from Current Periodicals

By A. Slobod

ELECTRO-CULTURE

In his inaugural address delivered before the Institution of Electrical Engineers, London, President Llewelyn B. Atkinson gives a critical review of the recent progress in electro-culture. The position of the problem of electricity in agriculture does not, in his opinion, reflect great credit on our science.

Sir Oliver Lodge, in the fifth Kelvin lecture, in 1914, gave the results of experiments he and others had carried out, and, for some years past, reports have been periodically circulated of the great increases in crops of various sorts which have been obtained by the use of electrical discharges from wires suspended a few feet from the ground. But the results have been confused and contradictory and certainly have not reached a position of any degree of scientific certainty. This can be explained by the difficulties and uncertainties of crop experiment on a field scale with the variation in quality of soil, working methods, time of planting, etc. In the opinion of the author careful pot and plant laboratory experiment offers the greatest opportunity of determining the causes of the effects that have been observed.

During the war a representative committee under the chairmanship of Sir John Snell was formed and has since issued an interim report, dated April 2, 1919, describing certain preliminary field, small plot and pot experiments carried out. The results of these experiments were by no means conclusive, as is stated in the report; nevertheless, one or two definite results emerged: (1) That, with currents of the order 10×10^{-9} ampere per plant passed from a charged wire through the air to the plant, the results of an electric current are clearly injurious. (2) That, in the case of young plants at least, the vegetative growth of plants was accelerated by currents of the order 0.3×10^{-9} ampere.

After reviewing for the benefit of the electrical engineers the scientific principles of horticulture involved in the solution of this problem the author states that while there is nearly always an air of mystery about the discussions of electro-culture the questions to be answered are simple. Does any system of electrification promise to increase the quantities of the availability of any of the primary food necessities of the plant or to augment the rate of or total absorption of the plant foods, and if so, at what cost? It may be at once said that the presence of a highly charged conductor with a corona discharge therefrom cannot augment the quantities of any of the food materials necessary in the soil except the nitrogen. It is conceivable, but improbable, that it will increase the rate of solution of the natural soil elements. The possibilities are: (1) Direct stimulation of growth processes, in fact replacing sunlight. (2) Increase of transpiration of water. (3) Decrease of evaporation from the soil, equivalent to providing more moisture. (4) Production of nitrates. (5) Ionization of nitrogen or carbonic acid so as to be more readily absorbed by the soil bacteria or the plant. (6) Sterilization of the plant.

Of these (1), (2), (3) are purely electrical if they exist; they are direct actions and would occur in the region immediately under the wires. Many experiments have shown, however, that the effect, whatever it is does not occur necessarily directly in the near neighborhood of the wires used to maintain the electric stress, or to give the electric discharge, but that the effect may be to one side or the other of the electrified plot, and it appears that this result is not strictly electrical at all, but due to something produced in the neighborhood of the wire, which is heavier than air, but can be diverted by the prevailing wind.

If this is the case we are thrown back on the causes (4), (5), (6). The researches of Earl Warner and Jakob Kunz at the University of Illinois have shown that the corona discharge in air causes ionization of nitrogen, oxygen and carbonic acid; the researches of Prof. J. Strutt and Dr. Lowry upon the action of the silent discharge have shown that active forms of nitrogen are the result. The discharge in carbonic acid produces oxygen; in air with water, ammonium nitrate. The fact then that chemical active ions and compounds are produced which would move with the wind, points to these being the cause of the observed results. If the results were due to the production of nitric acid one would expect the increase to be greater the greater the current, but, on the contrary, the results were better with smaller currents. A similar agreement would seem to hold in the case of the ionization of carbonic acid.

The results obtainable in increased crops by the sterilization of the soil are very remarkable. Recent researches have shown that one of the most powerful sterilizing agents known is oxide of nitrogen, one part in 50,000 parts is sufficient to kill any germ with which it comes in contact. It seems to me, therefore, that we have here the possible solution of the effect of electrical discharges over plants. A crucial experiment would be to compare the action on plants growing in soil, and in water with the plant foods dissolved therein. If the water-culture plants were unaffected and the soil-grown plants benefited, then I think the case for soil sterilization would be made out; if the reverse it would point to nitrate being the cause. It would appear as if the different effect of strong discharges and weak discharges may be in this, that strong discharges produce products other than oxides of nitrogen while weak discharges produce the sterilizing effect described.

The Wohler process of so-called electrification of seeds has also been boomed by the papers. The process consists in placing the seeds in a solution of 2½ to 5 per cent household salt and passing an electric current through the solution, then drying the seeds and sowing them. Even assuming the solution to be effective, it is difficult to see what result would accrue from the electric current unless it was a possible deeper or more rapid penetration by electro-osmosis. Careful experiments however by Dr. Hall at Rothampstead led him to conclude as follows: "The writer is not prepared on present evidence to say that the process never succeeds, but the risk of failure seems so great that the farmer should look upon it as an adventure which may or may not prove profitable." Mr. Martin Sutton, of Reading, after exhaustive trials, arrived at what was practically a negative result.—*Journal of the Institution of Electrical Engineers*, December, 1920, pp. 13-15.

OIL PROSPECTING BY ELECTRIC WAVES

Mr. R. S. Bruner, an electrician of twenty years' experience, has been demonstrating in Oklahoma City, Okla., what he calls a radio oil-locating instrument. He has already made field tests with his truckload of equipment. Without knowledge of the territory in which he was operating, and without having been advised of formation in test wells, his estimates of the depth of oil sands have been within 30 feet of their actual depth. Where no sands had been discovered he reported that no sands existed to the depth of the instrument's range. Something like 40 setups have been made, and no errors have been recorded in Bruner's conclusions.

The equipment consists of two engines and generator sets connected in parallel to supply the source of power and detector units and receiving equipment. The generator sets supply direct current at 40 volts. This applied to a 1-kilowatt motor-generator set creates 110 volts of alternating current,

higher voltage is then obtained through a step-up transformer. Connections are made from the high-voltage transformer through a suitable oscillation transformer, condenser and choke coils to earth contacts. This comprises the disturbing element and the equipment is all mounted on a truck which is readily transported.

A surveyor's transit is used in making a location for a test. Five earth connections with the disturbing machinery are then made, two of them set 100 feet apart in the magnetic north and south, and the other two at right angles and 50 feet apart. The master earth connection is a fifth rod which is placed in the exact center of the outline of the four other earth terminals. The detector units and receiving equipment consist of three complete radio receiving instruments, two of which are evenly balanced. The third acts as a detector in approximately the same manner as a galvanometer acts in a Wheatstone bridge arrangement. Through the aid of a number of vacuum tubes and honeycomb inductance coils properly connected and adjusted to the earth connections, an instrument of extreme sensitiveness is produced which reproduces the slightest variations through telephone receivers.

Working in unison with the receiving equipment are two instruments that verify by illustration that which the receiving instrument gives to the ear. One is a sensitive ballistic galvanometer and the other a photographic apparatus. Mr. Bruner is convinced that the resistance theory heretofore employed in tests with instruments of this nature is wrong. Directing his attention to radio apparatus and applying it to different substances below the earth's surface he was convinced that the different sounds obtained from distortion of wave lengths directed and adjusted to different materials in the earth's crust would, when calibrated to known standards, denote the presence or absence of materials.

The tests Mr. Bruner made are carefully charted both as to sound from the receivers and readings of the ballistic galvanometer, the photographic device furnishing a permanent record. Results in tested areas have come within a few feet of accuracy, and an accuracy within 50 feet is guaranteed by Mr. Bruner.—W. F. Kerr, *Electrical Review*, Chicago, Vol. 78, pp. 145-146, Jan. 22, 1921.

WORLD'S FIRST 220,000-VOLT POWER TRANSFORMER

The line voltage of 220,000, which has been tacitly agreed upon as being the approximate economic potential for the interconnections of the Western power systems, constitutes a very abrupt step in the curve of maximum transformer voltage. Nevertheless, there is every indication that the use of 220 volts will be attended with just as much success as that which characterized the first operation of 150,000-volt apparatus. A definite move in the direction of the 220 kilowatt pressure was made by the Southern California Edison Company last summer when an order was placed with the General Electric Company for four water-cooled, 50-cycle, 8,333-kva. transformers arranged for operation at 220,000 volts, stepping from a generated voltage of 11,000. These transformers are now being manufactured in the Pittsfield works of the General Electric Co., and their features are discussed by Clinton Jones in *Electrical World* for February 5, 1921, pp. 301-303.

The extensive investigations and experience of the General Electric Co. have proved the great advantages of the circular coil for high voltage transformers. After discussing these advantages in detail the author proceeds to describe the transformers under construction. It is of the "core" type with two groups of windings on separate core legs for each phase. The line end of high-voltage winding is brought out through a new standard oil-filled 250,000-volt bushing which is interchangeable as between the transformers and high tension oil circuit breakers. It will be interchangeable with any other bushings for 220,000-volt apparatus which may be furnished later. The external shell of this bushing consists of two porcelain pieces above the transformer cover, one porcelain piece below the cover and an intermediate metal cylinder which is flanged at the upper end to support the bushings. This metal portion always extends below the transformer oil level to avoid any possibility of corona in transformers having an air space between the oil level and cover. A metal tube extends from top to bottom through the center of the bushing, and the intervening space between this tube and the porcelain shell is filled with transil oil and concentric cylindrical insulating barriers. The glass chamber at the top provides space for expansion of the oil and indicates its level. The joints between the shell sections are made with treated cork gaskets compressed locally by numerous bolts engaging metal clamping rings. The central tube serves as the conductor when used in a breaker and as a conduit for a cable conductor in a transformer. The bushing has a dry flash-over voltage of 660,000. The lighting flash-over is estimated at more than twice the normal frequency figure and is equal for wet or dry conditions. In the event of any high impressed voltages the bushing will not puncture but will arch from the terminal to the ground.

The containing tank is of the "oil conservator" type, having a separate chamber for oil expansion. The principles involved in this construction are the elimination of the usual air space above the oil in the main tank and the isolation of the hot oil and transformer insulation from the surrounding air. The main tank is always completely filled with oil, and pressure is prevented by opening the auxiliary tank to the outside air through a breathing device. Any accumulation of moisture in the auxiliary tank due to condensation is caught in a sump and may be drawn off through a pet cock at the bottom. This construction eliminates "breathing" in the main tank and keeps the oil absolutely dry. It avoids explosions due to a possible mixture of air and gas formed from hot or decomposed oil. It protects the oil from "sludging," and preserves the transformer insulations.

ELECTRICAL AIDS TO NAVIGATION

Experiments were carried out at Brest with the object of making it not only possible, but easy, for a ship to enter or leave port with safety in thick fog. An armored cable is laid on the sea bottom along the channel leading in to the port, and the sea end of this cable is earthed. The cable is fed with alternating current having an audible frequency. In the experiments dealt with a current of 2.5 amp. was employed. The cable current creates in the space around the cable an alternating magnetic field of the same periodicity as that of the current. The lines of force are somewhat complex, and the distribution was investigated both in the sea and above the surface. In both cases the lines are in planes perpendicular to the cable. The apparatus on board the ship comprises two vertical coils 2.5 cm. $\times$ 10 m. for receiving the current induced by the cable field. Each coil has two windings of 60 and 10 turns, respectively; the first coil is athwart ships and the second, lying fore and aft. Leads are taken from these coils to the listening point on the bridge, and by using an amplifier the signals transmitted along the cable have been heard at distance of 2,000 m. When the ship approaches the cable at right angles, the receivers of the first coil give gradually increasing signals, while stronger signals are obtained on the second coil when running parallel to the cable. Two horizontal coils (2.5 m. x 1 m.), one to starboard and the other to port, as far apart and as high as possible, will receive signals at ranges up to 600 m. from the cable. The one which is nearer the cable will give the stronger signals, and by using two such coils it is easy to determine on which side of the ship the cable lies, when the ship is running parallel to the cable. Dirigible balloons and aircraft generally can follow a submerged "leader" cable if they are properly equipped. The range of reception of signals at 200 m. altitude is about 3,200 m. in breadth. At 600 m. it is stated that the range is 5 km. on either side of the cable. The cable used at Brest was 80 km. long, extending past the dangers of Ouessant and the Pierre Noires, the sea end of the cable being at a depth of about 100 m.—W. A. Loth, *Comptes Rendus* . . . de l'Academie des Sciences, Vol. 171, pp. 668-669. Ocotober 11, 1920.

Survey of Progress in Mechanical Engineering

Prepared Under the Auspices of the American Society of Mechanical Engineers

MARTIN ROTOR BALANCING MACHINE

Description of a simple device for balancing rotary bodies of particular interest because of its great sensitiveness. This latter is such that, for example, when balancing a rotor of 10,000 kg., a variation of 1 kg. cm. can be easily discovered by sliding a weight of 1 kg. along the beam. This corresponds to a deviation of the center of gravity of the rotor in a horizontal direction off the axis of 0.005 mm. or approximately one-fifty-thousandth of an inch.

The same result is expressed in a different way, as follows: When balancing a 10-ton Zoelly rotor of 6 ft. diameter, an overweight of 10 grams (one-third ounce) on its circumference, or one-millionth part of the rotor's weight, can be readily detected.

Furthermore, the apparatus indicates the correct plane in which this overweight lies and in which its moment acts. These results are obtained without rotation, as it is merely necessary to turn the body to six or eight fixed positions and when actually balancing no rotation takes place. Because of this the method is not affected by the inertia of the body and the angle of lag cannot affect the results.

The machine (Fig. 1) consists of two main portions arranged to support the shaft of the rotor to be balanced. At one end the shaft is hung in a universally jointed stirrup and at the other in a bearing which is mounted on a short arm of a steelyard lever.

Having placed the rotor to be balanced in the bearings, the main weight of the steelyard is adjusted so as to bring the arm into equilibrium. The rotor is then turned a few degrees and the arm again adjusted by moving the jockey weight; this adjustment is recorded. The rotor is then turned through another section, and the necessary adjustment again made by means of the jockey weight, and so the process is continued for a complete revolution. The results are plotted to a horizontal base, and the sine curve obtained shows a maximum and minimum which indicate the points at which the center of gravity is farthest from, and nearest to, the supporting point of the balance. By multiplying the jockey weight by its displacement, a moment is derived from which the eccentricity of the center of gravity and the necessary correction are obtained.

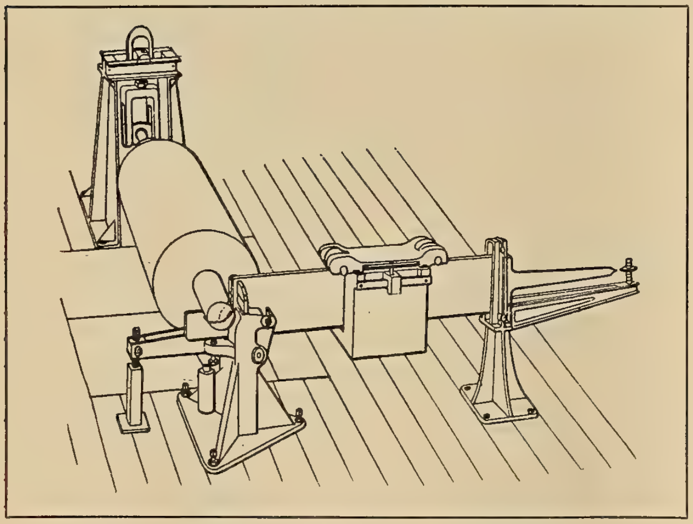


FIG. 1. MARTIN ROTOR BALANCING MACHINE

On all built-up turbines, such as the Zoelly and Curtis types, first the shaft and then each disk put on is successively balanced; the final balance obtained will then be without any disturbing couple, and many times more accurate than any result obtainable by other methods. In a drum-type turbine, such as the Parsons rotor, the overweight is taken out partly at each end in relation to the position of the center of gravity, the sum of this moment being equal to the total moment of overweight. Reduction gear wheels can also be balanced by this machine, and for bodies which are of relatively large radial and small axial dimensions, a mandrel (in itself balanced) to take such parts can be used on the machine. The machine could also be used for standardizing rotary parts. —*The Electrical Review*, Vol. 88, No. 2253, Jan. 28, 1921, pp. 101-102.

HYDRAULIC PROPULSION OF SHIPS

Hydraulic or reaction propulsion of vessels whether on air or water is an old idea and has been tried many times, though never successfully so far.

The reaction propulsion has certain advantages, the first of which being the relative simplicity of the propulsive equipment and elimination of the propeller with its appendages, which means not only fewer parts but absence of a rapidly rotating element outside of the ship hull subject to fouling and breakage. The elimination of the propeller leads also to the reduction of vibration. To this is added the ease with which the motion of a hydraulically-propelled boat may be reversed simply by deflecting the stream forward without even reversing the prime mover. This adds to the ease with which the vessel can be maneuvered and makes it possible to eliminate the rudder, another element outside of the ship hull subject to all kinds of untoward accidents.

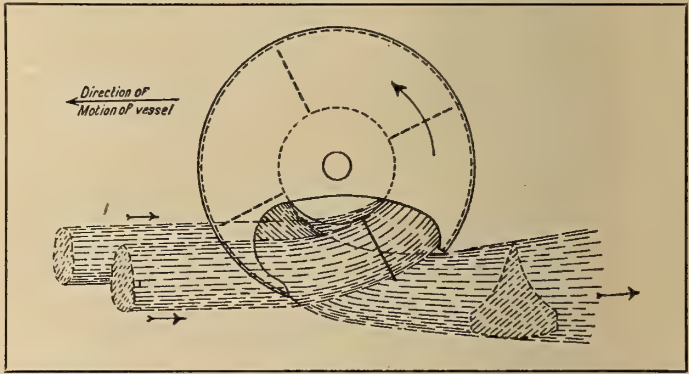


FIG. 2. DIAGRAM OF THE HOTCHKISS PUMP USED FOR REACTION PROPULSION OF SHIPS

Finally, the thrust developed by the discharge of the stream of water is independent of the depth at which the stream is discharged, while the depth of immersion of a screw propeller greatly affects the thrust. From these considerations it follows that racing cannot occur in a hydraulically propelled boat. In addition, the depth of water in which the ship operates efficiently is limited solely by the draught of the hull and not by the draught required for the efficient working of the propeller. Among the disadvantages cited against hydraulic propellers the chief is lack of efficiency. Various causes have contributed to the lack of efficiency shown by the systems tried in the past. If we regard hydraulic propulsion as consisting simply of the use of an internal propeller, it is obvious in the first place that loss will occur by virtue of the fact that the stream of water has to be brought to and discharged from the propeller through pipes and passages or orifices of some description. The frictional losses in such passages have no

counterpart in the external propeller, for in this case the water is drawn from and discharged into the immediately surrounding fluid. Again, in reaching and leaving the internal propeller, the water may in its flow be called upon to change its direction of movement to a considerable extent with a consequent considerable loss of energy. The water passages, too, may change in cross-sectional area, and as a result loss will arise by the conversion of pressure into velocity and velocity into pressure.

Lately, however, several reaction propulsion systems have been tried out. The Melot system as applied to aircraft has been described in *The Journal.*

The Hotchkiss and the Gill systems have recently been tried out for watercraft.

The Hotchkiss system was tried on a weldless steel launch measuring 24 feet in length overall and 6 feet 3 inches in beam with a draught of 1 foot 5 inches on a displacement of two tons. The machinery propelling the vessel consisted of an 8-b.hp. motor coupled through reduction beveled gearing to 2 Hotchkiss pumps.

The general principle of the Hotchkiss system is illustrated in the diagram of one of the pumps in Fig. 2. The pump consists of a four-bladed impeller rotating within a cylindrical casing, in which are formed three openings, namely, one in the lower half of each vertical side, and one in the lower portion of the periphery. In the diagram the two strips of the casing separating these three holes are represented as having been cut out, so that the holes really form but one hole. It will be convenient, however, to regard them as being in three. The casing is considerably wider than the impeller blades, so that between the edges of the blades and the vertical walls of the casing there is a passage on each side of considerable area.

In the diagram the movement of the boat is supposed to be toward the left. The impeller is driven in the direction of the arrow shown against it, and creates a vortex inside the casing. The water is drawn into the casing in two streams through the two side holes. Inside the casing these two streams converge, and finally become one, which, passing centrally between the two entering branches, is discharged sternward. The peculiar section which, according to Mr. Hotchkiss, the discharge stream assumes will be noted. It enables the discharge stream to pass between the entering streams without touching them, while at the same time it fills up nearly all the vacant space between them, on the assumption that the entering streams are circular or oval in section.

The essential feature of the Hotchkiss system is thus the creation of a vortex that travels along with the vessel. The water is drawn directly into the vortex without the intermediation of pipes or conduits of any description, and, therefore, frictional losses are practically avoided. The relative momentum of the incoming water, it is claimed, is not lost, but forms part of the momentum of the discharge stream.

The system is still in the experimental stages and no reliable data as to efficiency are available. It is stated, however, that the boat developed 5.6 knots (9.46 ft. per sec.) with the engine running at 950 revolutions and developing 7¾ b.hp. The speed of discharge of the stream from the pumps is calculated by Mr. Hotchkiss to be 16.4 ft. per sec. Calling these two speeds v and V respectively, the slip is $(V - v)/V$, or 42.3 per cent. The jet efficiency is, in accordance with the usual formula, $2v\ (V + v)$, or 73 per cent. Mr. Hotchkiss takes the efficiency of the pumps at 90 per cent, so that the propulsive efficiency comes out at 65.7 per cent. Taking the efficiency of the engine at 75 per cent, the overall efficiency is thus 49.3 per cent. Such an efficiency would not be considered bad in a similar vessel propelled by screw.

These figures have not, however, been checked by any reliable outside authority and are cited merely because of the revival of interest in reaction propulsion.—*The Engineer*, Vol. 131, No. 3398, Feb. 11, 1921, pp. 140-142.

THE TURBINE PATENT FURNACE

Description of a furnace designed on the principle of the impulse turbine. In its construction the air trough corresponds to the nozzle and the fire bars to the blades of the turbine. The air for combustion is forced between the bars which offer but slight resistance and the design is such that each fire bar receives an equal amount of air which is distributed through the narrow air spaces in the form of fine spray. Fig. 3 shows the furnace applied to a Babcock water tube boiler. Its outstanding feature is the dead-plate (7 in the figure) which slopes downward, thus bringing the furnace from 3 inches to 5 inches lower than the ordinary level and giving more room for combustion in the furnace proper. Air is admitted through the chamber as required, through the door fixed under the first bridge. The fire bars are constructed with interlocking lugs so that they cannot be displaced by the rake, and the air spaces slant upward and backward reducing the amount of fine ash or coal that drops through to a minimum. The bottom lugs project forward and intercept the air, thus helping an evenly diffused supply throughout the fire. The grate consists of from four to six furnaces, each receiving its own air supply, which besides insuring an evenly burning fire makes the use of steam jets for creating the draught very simple.—*The Electrical Times*, Vol. 59, No. 1525, Jan. 6, 1921, p. 11.

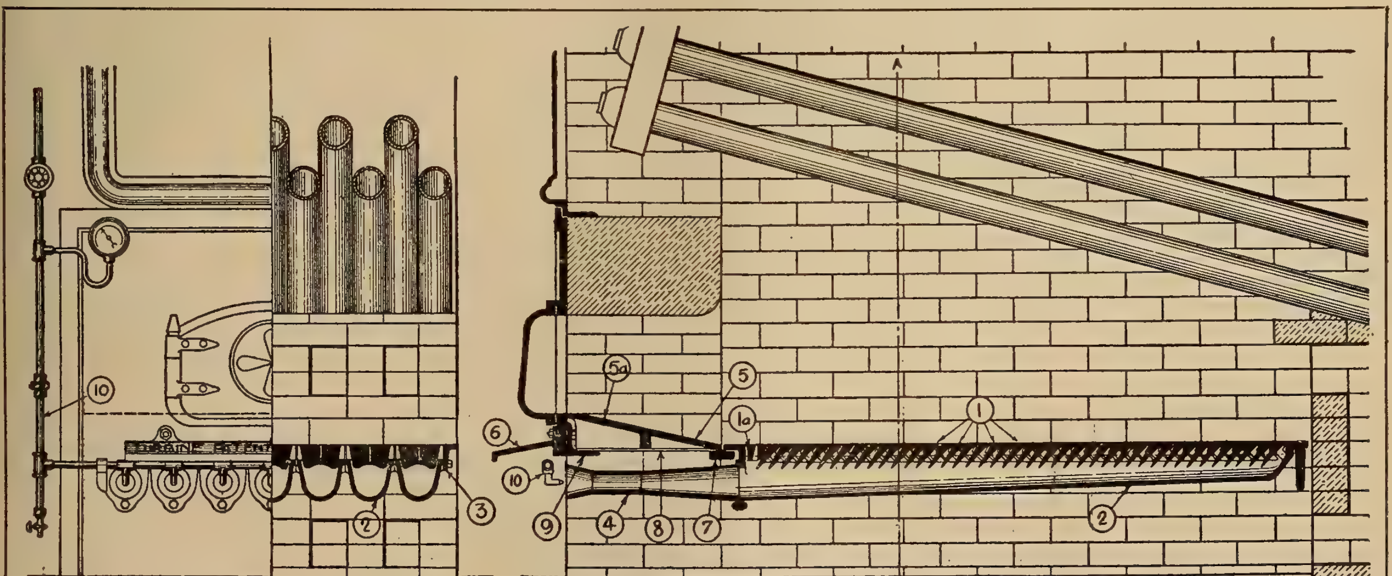


FIG. 3. TURBINE PATENT FURNACE AS APPLIED TO A BABCOCK WATER-TUBE BOILER

LEITNER-WATTS ALL-METAL PROPELLER

It is stated that all but one of the problems of the metal propeller have been solved in this device, and that one is weight. In their present form these propellers are very much heavier than corresponding wooden screws.

The blades are each made up in the form of a shell of sheet steel and the necessary taper in thickness is obtained by using laminated construction, there being three laminations—one at the top, the second about half way between the tip and the buss, and the third at the root. The laminations are at present riveted together but later on it is intended to employ electric spot welding.

The two halves of each blade are attached to one another at the edges only by welding, but in order to stiffen the shell thus formed small struts are placed between the two faces at intervals.

The method of inserting these struts is shown in Fig. 4. The struts are shouldered at both ends and the hole in one face of the blade is made just the right size to take the thin portion of the strut. In the other face of the blade is cut a hole large enough to accommodate the thick portion of the strut. From this hole runs a slot of a width corresponding to the shouldering portion of the strut. To place in position, the strut is inserted in the large hole, its other end being pushed into the small hole on the opposite face and the shoulder portion is slid into the slot. The strut is then screwed in position by soldering washers over the two strut ends.

The root of the blade is constructed in a rather substantial manner. Balance of the blades is secured by using small balance weights carried on short length of tube secured to the

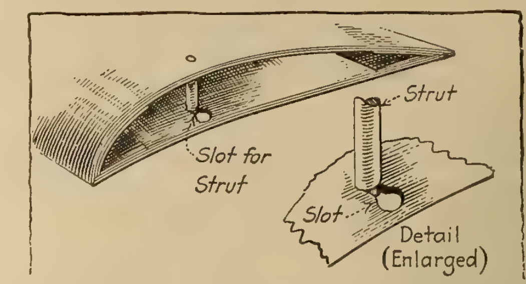


FIG. 4. METHOD OF INSERTING SMALL STRUTS BETWEEN FRONT AND REAR FACES OF THE LEITNER-WATTS ALL-METAL PROPELLER

inner end of the central plug in the blade root. These propellers have an adjustable but not a variable pitch, which means that the pitch angle of the blades can be altered over a wide range (10 deg. each way) thus making the propeller suitable for a number of different conditions by setting the pitch according to requirements.—*Aerial Age Weekly*, Vol. 12, No. 22, Feb. 7, 1921, pp. 559-560.

Progress in Mining and Metallurgy

Abstracts of Papers and Recent Articles

Prepared Under the Auspices of the American Institute of Mining and Metallurgical Engineers

COAL MINING IN SPITZBERGEN

By H. M. Cadell

Until 1920 Spitzbergen was a "No man's land," and although it was claimed as part of the British Empire 300 years ago, the claim had been allowed to lapse, and no other country considered the place worth acquiring. The value was considered to lie in the whaling resources of the region; and, although coal was discovered in 1610, the mineral possibilities of the territory were not seriously considered till the beginning of the present century.

In 1900 a Trondhjem company made an attempt to work the coal that had been found at Advent Bay, a branch of the Ice Fjord, but the financial resources of the concern soon became exhausted, and the claims were bought up, in 1904, for £1,000 by Mr. Longyear, an American, who, under the name of the Arctic Coal Co., of Boston, began to develop the coal field with great energy. It was worked by Mr. Longyear till 1916, when he sold his rights to the present owners, the Store Vorske Kulfelter of Christiania. Others, however, were exploring the ground when the war broke out.

No. 1 mine, worked by Mr. Longyear before 1916 produced about 200,000 tons of coal, and a similar amount was taken out by the present owners before the end of 1919. A piece of the Longyear coal of what seemed average quality analyzed as follows:

	Per Cent
Fixed carbon	57.15
Volatile matter	37.21
Sulfur	0.73
Ash	3.20
Moisture	1.71
Total	100.00

Calories, 7,850 = B.t.u., 14,130.

Heating power (theoretical) (pounds of water at 212° F. evaporated by 1 lb. of coal), 14.54.

Mining and boring operations have proved that the whole ground is frozen to a depth of several hundred feet, and so far none of the Spitzbergen mines has penetrated through the frigid zone, which may be 1,000 feet thick or more. The temperature of the Longyear mines remains uniformly at — 4° C., or about 7° F. below the freezing point of water, and this circumstance has important effects on mining and boring operations, which engineers trained in a temperate climate might never anticipate. In a diamond boring on the Ice Fjord at Klaas Billen Bay, after stopping for a short time, the borers found the hole frozen solid so that the rods could not be withdrawn, and subsequent bores had to be fed with a stream of warm water from a specially devised heater to prevent disaster.

Longwall mining can be carried on without the need for timber to support the roof behind the working face. The frozen roof is wonderfully strong, and the roadways resemble a fairy crystal grotto all crusted with hoar frost. If the roof is scratched, the delicate pendant ice crystals at once drop in a snowy shower. The sides of the roadways through the waste are built up with walls from the stone produced in brushing them, and in the course of time the roof settles down on the building and all is safe.

There is no doubt that there is a great coal field; at places far apart good coal seams extend over a large and accessible area near the sea, besides others that may be won later on, by sinking or working farther inland.

I am not in a position to form any useful estimate of how much coal there may be, but there are certainly two and perhaps more workable seams of good Tertiary and Cretaceous coal, a seam of Jurassic coal of inferior quality, and at least one workable seam of Carboniferous coal, not yet opened out. Mr. Högbom, in 1913,[1] estimated the Tertiary coal with an average thickness of 125 cm. (49 in.) to extend over 1,200

[1] International Geological Congress, *Coal Resources of the World* (1913).

sq. km. (463 sq. mi.), and to amount to 2,000,000,000 metric tons. The total thickness and therefore the quantity is probably much greater than he estimates, since we now know there are at least two workable seams of Tertiary or Cretaceous age extending over large parts of Spitzbergen. The quantity of Carboniferous coal he puts at a still higher figure, but this is a more doubtful estimate.

The advantages of coal mining in Spitzbergen include:

1. The seams of workable coal have been proved to be of high quality as a rule, although of somewhat variable thickness.
2. The field is everywhere very regular and free from faults or dikes, and the dip gentle, so that coal-cutting and conveying plant can be used to save labor and to extract all the coal to the best advantage.
3. The ground being all hard frozen, a strong roof is provided, and little or no timber is required underground.
4. There is no water requiring pumping.
5. The coal outcrops being mostly above or close to the shore, there need at first be no shaft sinking or railway transport to pay for, and ships can be loaded direct from the mine by aerial ropeways worked in many cases by gravitation.
6. Until 1920 there were no royalties, rates, or taxes to pay, and in future these are not likely to become a serious charge on working costs.
7. The climate, although Arctic, is extremely healthy.

Among the disadvantages are:

1. The Arctic winter, when for three months from the middle of November to the middle of February the sun is below the horizon and it is more or less dark, and only three to five months when the coast is clear of ice.
2. The disintegrating effect of the weather on stocks of coal produced in winter for shipment.
3. The possibility of dust in the dry workings.
4. The necessity of importing all supplies, including timber, building materials, food, and machinery.
5. The large excess of exports over imports, making it necessary for most vessels to come light or in ballast to Spitzbergen, and the insurance against risk from ice which tends to make freights relatively higher than in more temperate regions.—Abstract of paper presented before the Mining Institute of Scotland and published in the *Transactions* of the Institute of Mining Engineers.

APPLICATION IN ROLLING OF EFFECTS OF CARBON, PHOSPHORUS, AND MANGANESE ON MECHANICAL PROPERTIES OF STEEL

By Wm. R. Webster

The former discussion on the physics of steel started with the consideration of five papers presented at the Chicago meeting in 1893, and continued for several years. This paper will be devoted to the practical application, in rolling steel, of the effects of carbon, phosphorus, and manganese on its tensile strength, with some suggestions on further research work.

The variations in the values given by the different investigators for the increase of the tensile strength of steel for each 0.01 per cent of carbon, phosphorus and manganese were largely due to the steels they worked on, the large or small variations in the amount of the elements present, and the omission to take into consideration all the factors, from the blast furnace through to finished rolled material, that affect the character of the steel. For instance, a poorly made steel with the same phosphorus and manganese content requires considerably more carbon than a well-made clean steel to give the same ultimate strength.

None of the values given for each element will apply equally well for all makes of steel or to different works making the same steel. Of course, the development of the quick chemical methods has greatly assisted in this work, especially the quick combustion for carbon determination, which has generally replaced the old color carbons. Fortunately, several of our largest steel manufacturers have always relied on the work of different investigators and coöperated with them. These manufacturers deserve credit for this and for the practical working tables that have been developed and put into daily use at their works. They can now grade their steel and roll it into the finished product with much greater certainty of its meeting all requirements of the standard specifications than formerly, and with much less trouble than when they had to grade the steel from the results of the tension and bending tests of bars rolled from small test ingots from each heat.

When Bessemer steel was in general use for structural purposes, a base of 50,000 lb. per sq. in. was taken, to which 1,000 lb. was added for each 0.01 per cent of carbon contained in the steel. This worked fairly well as a guide, the base being high enough to include the effect of the average manganese and phosphorus contained in the steel, but the results of tension tests of bars rolled from small test ingots necessarily were used for grading the steel. When acid open-hearth steel came into use, the base of 50,000 lb. was found too high.

The importance of this is shown when we consider that there is only a range from about 45,000 to 85,000 lb. in tensile strength of steel used for structural purposes, and that 15 per cent of this 40,000 lb. difference is accounted for by the difference in the results from the same heat of steel when part is rolled into thick and part into thin material.

During the last seven or eight years, some steel works, from their own data and tension tests of rolled material of different weights and thickness on former orders, have made their own tables for rolling similar materials on new orders. The results are most satisfactory, as the makers have at once the data required to grade and roll heats of steel best suited to comply with the requirements of each order. These tables cover not only the thickness of the steel but all other rolling conditions at the particular mill for which the table is designed. Formerly, it would have been almost impossible to collect such data, owing to the large number of specifications in general use. It was through the work of the Steel Committee of the American Society for Testing Materials that steel specifications were standardized and many of the old specifications scrapped. The other engineering societies coöperated in this work, and the whole range of structural steel is now covered by about six subdivisions, the limits of each covering a range of about 10,000 lb. in tensile strength. Some of these overlap, as for instance, 55,000 to 65,000 lb. per sq. in. overlaps the 50,000 to 60,000 lb. and 60,000 to 70,000 lb. These standard specifications simplified matters very much.

In mill work, when grading good basic open-hearth steel, there is little need of considering the differences in the effects assigned to the unit of phosphorus, as the phosphorus in this steel does not generally vary more than four points, while the additions to the tensile strength, when estimated by the different methods referred to, varies from about 1,500 to 3,000 lb. per sq. in. Most of this is generally covered by the differences in the values given to the effects of manganese and carbon. Satisfactory results are obtained in rolling steel under all of these varying methods. There has always been a great difference in the opinions of investigators and manufacturers of steel regarding the effect of manganese on its tensile strength. Some claim that the effect was slight, others that there was no effect on basic open-hearth steel until the manganese was above 0.40 or 0.60 per cent., but most of them admit its effect on acid open-hearth steel.—*Mining and Metallurgy*, March, 1921.

THACHER MOLDING PROCESS FOR PROPELLER BLADES

By Enrique Touceda

For a number of years prior to the World War, the firm of Geo. H. Thacher & Co., of Albany, N. Y., was engaged in the manufacture of marine and other gray-iron castings. At the outbreak of the war the firm decided to specialize in the manufacture of propeller wheels. It attacked the problem therefore from a foundry point of view, seeking to produce a

propeller casting that would be so accurate that no subsequent machining would be required on the blades.

There were two general methods of manufacture, the shortcomings of which have been freely acknowledged. In the sweep method, the nowel, or bottom half-mold, for each blade is swept up by a spindle beam and pitch race, while the top half-mold for each blade is built up individually. In the pattern method one individual blade, with the hub or hub portion, is mounted on a spindle and the individual blade mold formed; the pattern is then rotated on the spindle to the position for the next blade, etc. Only in rare cases were wheels made from a solid pattern, owing to the cost of the pattern, its failure in many instances to be correctly made, and (when made of wood) its early and sure distorting. Metal patterns in most instances were prohibitive in cost. In these methods green-sand and loam molding was practiced. The casting produced by either method can be considered only as a blank from which the propeller must be machined. The back surface of each blade must be chipped to the templet and then chipped to such accuracy as will be required for a static balance. Inasmuch as the work done by the machine tool is confined to the driving face of the blades, not only is perfection most difficult, but corrosion will be greater because of the removal of the dense skin of the casting and the local strains set up by the pneumatic tool in chipping.

To produce a finished 9-ft. propeller for a Navy destroyer required from 8 to 21 days of foundry work and about the same length of time for the machining. Through the use of the Thacher process, only as many hours are required; besides, it is possible to produce a finished casting in perfect conformity with any particular propeller-wheel design. The method is fool proof against inaccuracy for each part of the mold is contained within and supported by a cast-iron casing, or container, the dowel pins of which are fashioned to engage accurately the holes in the casing, or bedplate to which it is to be attached. So accurately made are the various parts of the cast-iron flask that in the case of flask and mold equipments covering certain limiting diameters and pitches of wheel, any part of one outfit is interchangeable with the same part of any other similar outfit. A perfect propeller wheel was cast from a completely assembled mold made up in Albany that was shipped, uncrated, by ordinary freight to a foundry just outside of Boston.—Abstract of paper to be read at the Wilkes-Barre Meeting, September, 1921.

Correspondence

The editor is not responsible for statements made in the correspondence column. Anonymous communications cannot be considered, but the names of correspondents will be withheld when so desired.

SUPPRESSION OF TEETH OF RUMINANTS

To the Editor of the SCIENTIFIC AMERICAN MONTHLY:

LITTLE is known about the suppression of the teeth of Ruminants. It is however thought they at one time had full dentition. The variation in cows' teeth given here furnishes interesting speculation on the subject.

The specimen (Fig. 2) is the skull of a Jersey cow owned by George Elkins, Rogersville, Tenn. The tooth was discovered on the death of the cow and extracted by the writer, thinking at the time that it was merely a curiosity. The tooth was worn by a neighbor as a watch fob and lost. It was one inch long, having the normal shape of a lower front and articulated perfectly with the right lower front. The cow had a normal number (8) of lower front teeth. No other variation was noted. The cow had a progeny of four, none of which showed any variation. This appears on investigation to be the only case of the kind ever reported.

The absence of upper front teeth is a general characteristic of ruminants, yet rudimentary canines exist in some deer. Cuvier first pointed out that there was a relation between the presence of horns and the absence of canine teeth, the latter serving as weapons of sexual combat solely, while those with fully developed horns had no use for such weapons of offense.

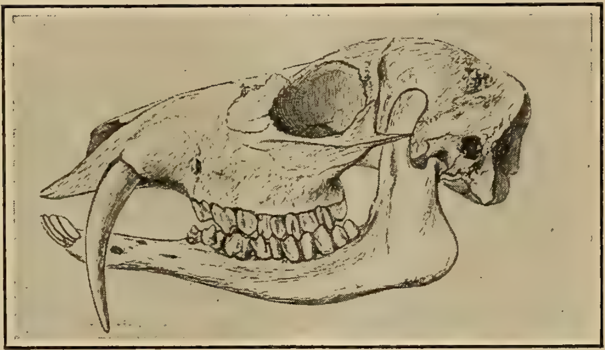


FIG. 1. CRANIUM OF MALE MUSK DEER (*MOSCHUS MOSCHIFERUS*)

From Jones Dental Anatomy
FIG. 2. SKULL OF COW WITH CAVITY, SHOWING AN UPPER FRONT TOOTH

According to Sir Victor Brooke: "The upper canines are present in both sexes in all the species of Cervidoe, with the exception of Alces, Rangifer, Dama and some smaller species. . . . The upper canines when present are, with the notable exception of Moschus, Elaphodus, Cervulus and Hydropotes, small latterally compressed rudimentary teeth. Their crowns are in about the same stage of reduction as the crowns of horses' canines, but their roots are relatively much more reduced."

The hornless musk deer (*Moschus*) possess upper canines of most formidable dimensions, while the female has very small subcylindrical canines.

The Indian Muntjac deer (*Cervulus*) has somewhat small horns, which are perched upon persistent bony pedicles, and it has upper canines which are curved outward from beneath the upper lip, much as are the tusks of a boar.

The theory was formerly advanced that uncalcified tooth germs were to be found in the foetuses of many species of the cow and sheep. This is now denied by almost all modern investigators. However, Miss Mayo (*Bull Comp. Zoöl. Harvard*, 1888), advances the idea that the suppression of the teeth has been progressive. She points out that in the region of the missing canine differentiation proceeds a little further than in the incisor region, though it never reached the stage of a real tooth germ. This supposition would mean that the incisors were lost at one period of evolution and the canines at a much later period.

M. V. KOGER.
Rogersville, Tenn.

Worthington Centrifugal Pumps

CENTRIFUGAL pumping problems solved by Worthington are many and varied. Centrifugal types developed through those lessons learned, have fallen naturally into two classes — special and standard.

Five types of Worthington "centrifugals" are manufactured in quantity — are standard apparatus. A baker's dozen of other types are made up from time to time to meet special conditions. Drawings and patterns for these special forms are ready for instant use.

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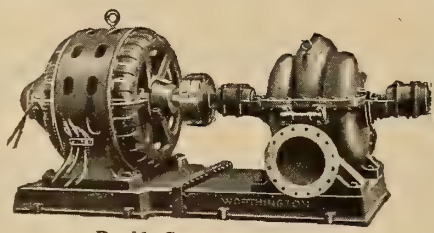
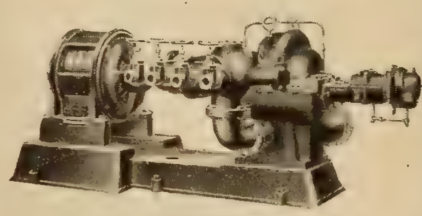
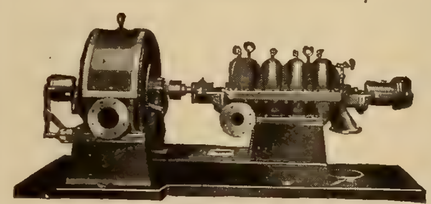


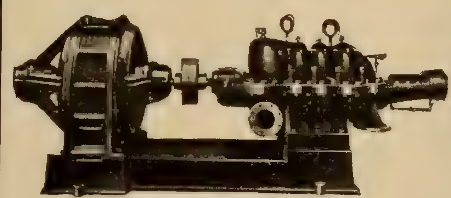
Double Suction Volute Pump



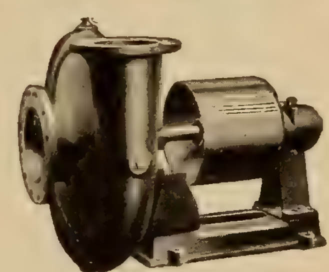
Centrifugal Underwriter Fire Pump



Centrifugal Boiler Feed Pump



Multistage Centrifugal Pump



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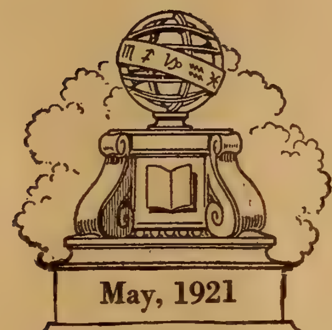

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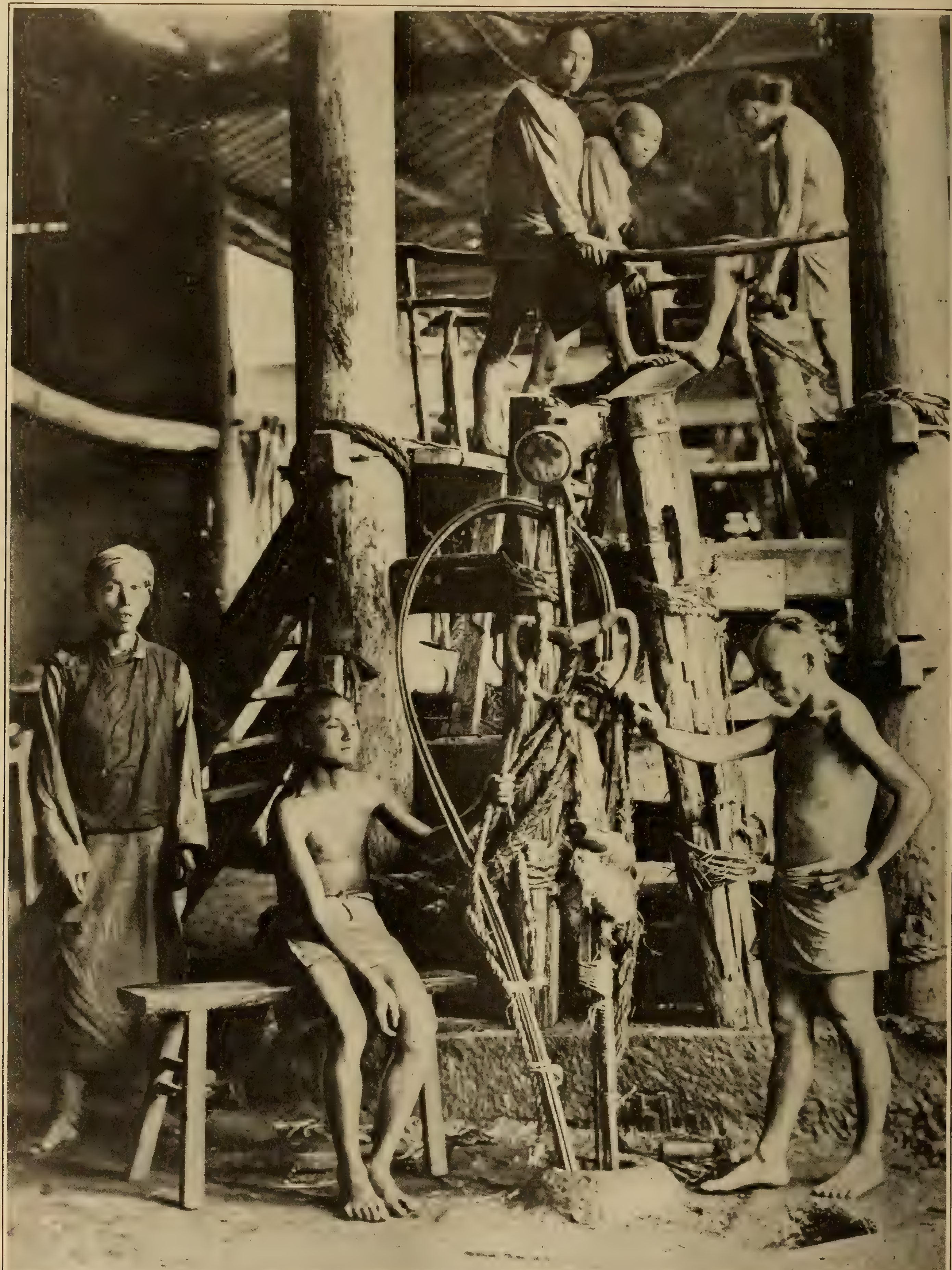

THE SALT WELLS OF CHINA—DRILLING A SALT WELL AS THE CHINESE HAVE DONE IT FOR CENTURIES
(SEE PAGE 427)

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VOLUME III
NUMBER 5

NEW YORK, MAY, 1921

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TO OUR READERS

THIS is a plea for counsel. We are trying to perform a real service to our readers—to produce a journal that will be indispensable to the lover of science and to the man who would keep abreast of the progress of technology. How nearly this purpose is fulfilled we can only tell by hearing from our readers.

Were our field confined to a single branch of science, it would be a simple matter to keep pace with all the latest developments, but we are trying to cover the whole realm of science. The avenues of research are so many and varied, progress is so rapid, there is so much to crowd into our limited number of pages, that we must ever struggle with the problem of what to leave out. Our choice would be better guided if we knew what subjects were of superior interest to the majority of our readers.

Accordingly, dear reader, will you not give us the benefit of your criticism and advice? Tell us what branch of science interests you most. What subjects would you like to see treated at greater length? Is there any field which, in your opinion, we are neglecting, or to which we are devoting too much space? Do you read the SCIENTIFIC AMERICAN MONTHLY for the pure love of science and progress? Do you derive any industrial or commercial benefit from it?

Constructive criticism is invaluable to an editor. Answers to the questions we have put will help us to produce a journal which will be of highest interest and real service to you.

THE MENACE OF THE HORSEHAIR SHAVING BRUSH

THIS world seems to be getting more and more dangerous to live in. We are beset on all hands with enemies, the deadliest of which are minute organisms visible only with the aid of a powerful microscope. Some indeed, we suspect, are so small that even the microscope fails to reveal them. In most cases we do not even know which of the infinite varieties of bacteria are our enemies. Only a few as yet have been definitely identified. Their insidious methods of attack and the subtle means by which they gain admittance to our bodies are so many and varied that absolute exclusion is well-nigh impossible. The precautions we must take to guard against their invasions are growing more and more irksome and have added materially to the complexity of living.

One of the first of these minute organisms to be isolated was the anthrax bacillus. The chief field of operation of these militant microbes is in the bodies of herbivorous animals, both domestic and wild, and through the domestic animals, the bacteria gain access to man. Indeed, anthrax used to be a dread scourge of human populations until proper sanitary precautions were taken and adequate means developed for combating the disease.

Recently an unusually large number of cases of anthrax were reported in New York City and a search was instituted to discover the breach through which the deadly germs had broken in. Eventually the search narrowed to an apparently innocent toilet article, the shaving brush. To be sure shaving brushes in insanitary barber shops will carry disease from one patron to another, but here the case was much more flagrant. New brushes that had not previously been used served as the medium for introducing the dread disease. The brushes were of a cheap class made from horsehair. Examination of the brushes revealed the fact that they carried the spores of anthrax. Evidently the hair had been taken from diseased animals and had not been properly sterilized. The shaving brush although the chief offender was not the only one; other brushes also stood convicted with the criminal evidence upon them. Fully 80 per cent of the brushes tested were found to carry anthrax, and the spores were also discovered upon cloth and braid made of horsehair. Articles made from hog bristles are not liable to be infected because the process of treatment which they undergo removes the contamination.

During the war a great many hides were brought into New York City, and also a large amount of horsehair, which evidently had not been thoroughly inspected. Out of thirty-four cases of anthrax in New York City, eighteen were traced to the use of infected shaving brushes, and of these nine were fatal. In addition to this there were a number of operatives in factories who were infected with the disease during the manufacture of shaving brushes, and also in the treatment of hides. One case was traced to the use of a table crumb brush, which proved to be infected with spores of anthrax.

As a result of these cases the Board of Health of the City of New York has adopted regulations requiring that all hair used in the manufacture of brushes and cloth be sterilized under processes prescribed by the Board. The sale of brushes is also forbidden without having the word "sterilized" permanently and clearly branded upon the article and this word cannot be applied to the article until it has been sterilized under the direction of the Board of Health.

The spores of anthrax are particularly difficult to destroy. They resist ordinary disinfecting; they will actually pass through tanning and bleaching solutions and still retain their activity. Mercuric chlorid, 1:2500, with 1 per cent of formic acid has been used to destroy the germs, also forty-eight hours' exposure to 2 per cent hydrochloric acid with 10 per cent sodium chlorid, but these measures have not yet been proved absolutely reliable.

In view of the difficulty of destroying the spores, and also in view of the difficulty of eliminating contaminated horsehair from the market there is need for a national prohibitive act banishing horsehair shaving brushes, and requiring all manufacturers using horsehair thoroughly to sterilize the product before making it into toilet articles.

Infinitely Small and Infinitely Great

Lengths, Volumes, Masses, Velocities, Etc., at the Limits of Measurement

By Georges Estoppey

INFINITELY small! Infinitely great! This subject is so vast that we shall describe it superficially only. To give all details, to explain how the following values have been determined, would be impossible within the limits of an article such as this.

Logically speaking, the infinitely small is inconceivable and has no limit. Similarly, the infinitely great is immeasurable and has also no limit. But, in the following description, we shall be more tolerant with these two expressions, and we shall apply the term "infinitely small" to particles or corpuscles susceptible of being analyzed, and we shall apply the term "infinitely great" to masses or distances susceptible of being measured. We shall try to give an idea of the size of everything which is around us, in comparing them as much as possible with the size of man, with his power, with the speeds he has attained with his swiftest vehicles.

RELATION OF THE INFINITELY SMALL TO THE INFINITELY GREAT

The Meter Taken As Unit

0,000.000,000,000,000,001	*Diam. positive nucleus*
0,000,000,000,000,001	*Diam. negative electron*
0,000.000,000,001	*Diam. of atom*
0,000,000,001	*Length of ultra violet waves*
0,000,001	*Micron*
0,001	*Diam. of a mite*
0.1	*Diam. of an orange*
1	*METER = 39.37 INCHES*
300	*Eiffel tower height*
8,890	*Altitude of Himalayas*
24,000	*Diam. of the smallest asteroid*
3,500,000	*Diam. of the moon*
12,700,000	*Diam. of the earth*
384,000,000	*Dist. from earth to the moon*
150,000,000,000	*Dist. from earth to the sun*
8,880,000,000,000	*Diam. of Neptune's orbit*
40,000,000,000,000,000	*Dist. earth to α Centauris*
430,000,000,000,000,000	*Dist. from earth to polar star*
2,000,000,000,000,000,000	*Dist. from earth to the farthest star situated at the limit of the Milky Way*
4,500,000,000,000,000,000,000	*Dist. from earth to the nearest nebula situated outside of the Milky Way*
100,000.000,000,000,000,000,000	*Dist. from earth to the farthest nebula*

The last number is only an estimated value since it cannot be measured exactly

If we look only superficially at what we see around us, it seems that man takes the most important place in the universe. Let us not pride ourselves on such a high conception, but let us search, let us analyze, let us try to lift the mysterious veil of nature—in this alone may we take pride.

Now let us speak of the most infinitesimal objects known. Let us first observe a minute drop of clear water through the lenses of a powerful microscope. What shall we see? Millions and millions of infusoria which are circulating with tremendous speed.

Concerning the atom, which was for a long time considered the smallest particle of matter, do you know how many atoms there are in a pin head? Eight thousand of billions of billions! 8,000,000,000,000,000,000,000—and this is not yet the limit since the atom is composed of a great number of electrons which represent the most infinitesimal particles that man can measure. And now, what is the size and power of man as compared with the size and power of these minute particles? Infinitely great, shall we say? . . . Never mind; man is only infinitely small compared with objects around him. And then, our terrestrial globe; how does it compare with man? Infinitely great would we say? Not at all. This earth on which we dwell, this earth which evolved in boundless space through millions and millions of years, is but a particle of sand in our planetary system, and our planetary system is only an imperceptible point lost in the immensity of our stellar system and this system no matter how extensive it may be, is still infinitely small as compared with the universe which is infinite.

Now that we have an approximate idea of the subject which will be described in the following lines, we shall go into further details.

The subject will be divided into several chapters. The first one will treat of lengths in which we shall speak about the diameter of the electron, of the atom, of the earth, and of the sun. We shall also speak about the distances from the earth to the farthest stars and nebula. The next chapter will deal with the subject of speed, energy, calorific and luminous powers, weights, time, inter-atomic energy and of smallest organic corpuscles. We shall also say something about the physiological effects produced by the number of sounds and luminous waves. Then, we shall try to give an idea of the enormous dimensions of space that can be detected by the most powerful telescope and, finally, we shall establish the relation between the minima and the maxima that man can measure. And when we shall have paved all the steps of the enormous chains which bind the infinitely small to the infinitely great, we may conceive of the space that man occupies in the universe.

LENGTHS

Let us take as our standard the meter (39.37 inches) which is one ten millionth part of a quarter of a terrestrial meridian.

Meter = 1.

The millimeter which is equal to $\frac{1}{25}$ of an inch is one thousandth part of a meter.

$$1 \text{ millimeter} = \frac{1}{1000}$$

This dimension will no doubt appear very small to persons who are not accustomed to such small fractions.

The "micron" represents the millionth part of a meter

$$1 \text{ micron} = \frac{1}{1{,}000{,}000}$$

The micron is the linear unit that physicists use to determine the length of luminous waves. The symbol of the micron is represented by the Greek letter μ. The lengths of waves of the visible spectrum varies from 0.4 μ to 0.8 μ. The ultra violet rays have a wave length of 0.1 μ. These dimensions may seem to be the limit of the infinitely small that can be conceived. Never mind. This value is still very large as compared with atom which is the smallest particle of ponderable matter. The atom, the diameter of which is 10^{-8}C is ten thousand times smaller than the micron.

$$\text{Diameter of the atom} = \frac{1}{10{,}000{,}000{,}000} \text{ of a meter.}$$

This exceedingly small dimension is still one hundred million times larger than the positive electron (nucleus) this particle of which the diameter is 10^{-16}C is the one billion billionth part of a meter.

Such is the smallest dimension that man is able to determine by mathematical and experimental deductions. Is it possible to conceive of such a tenuous particle? To obtain a meter we must put side by side one billion billions of such a particle. Let us try to give an idea of this enormous number. Supposing that a man counted this number at a rate of one million per second; he would have to live not less than ten thousand years to complete the count.

Let us proceed in the opposite, taking again the meter as a base of our comparison

Meter = 1

The highest building in the world is the Woolworth Building which reaches a respectable height of 270 meters. The Eiffel Tower in Paris measures 300 meters. The highest mountain in the world is Mt. Everest which raises his head to an altitude of about 8,890 meters. The greatest depth measured in the Pacific Ocean is about at 9,000 meters deep. The diameter of the earth is 12,700,000 meters. Supposing that an airplane is flying consecutively at a speed of 200 miles an hour, it would take a little more than 5 days for this airplane to make a single trip around the earth, the circumference of which is 40,000,000 meters. The distance from the earth to the moon is 380 million meters. The diameter of the sun is about 3.6 times larger than the distance from the earth to the moon or 1,380 million meters. It would take more than 1½ years for our airplane to fly around the sun. The distance from the earth to the sun is 150 billion meters. To make the circuit of Neptune's orbit, the diameter of which is about 9 thousand billion meters, our airplane would have to keep going for 3,500 years. Alpha Centauris, the nearest star, is 4½ light years distant from us or 42 millions of billions of meters (42,000,000,000,000,000). The large and magnificent nebula of Andromeda has a diameter which measures 386,500 times the distance from the earth to the sun. It takes about 6 years for light to cross this space. The distance is equal to 58 millions of billions of meters (58,000,000,000,000,000). It would take more than 23 million years for our airplane to pass through this nebula which is about 6,000 times larger than our planetary system. The polar star is 46½ light years from us, and its distance is equal to 440 millions of billions meters (440,000,000,000,000,000). The light of the farthest star, at the confines of the Milky Way, is taking about 2,000 years to come to us. This star is shining at a distance equal to 18 billions of billions meters (18,000,000,000,000,000,000). The giant star Betelgeuse, the diameter of which is 300 times larger than that of our sun is at a formidable distance of 180 light years. And that is not yet the limit of distance which can be perceived. A powerful telescope searches spaces at a much greater distance. Let us go out of our stellar system and let us see what is outside the Milky Way. The nearest nubula belonging to the stellar system that is nearest to ours is at more than 45,000 light years from the earth, or at about 400 billions of billions meters (400,000,000,000,000,000,000). And at last, the farthest nebula that the telescope permits us to perceive is estimated by Dr. Prud'honme to be at a distance of something like several millions of light centuries from our earth. Let us be satisfied with a distance of 10 million light years, which is sufficiently formidable for us. Figured in meters, this distance would be equal to 90 thousand billion billion meters (90,000,000,000,000,000,000,000). Let us try to gain an idea of such a fantastic number. The sun is 150 billion meters from us and seems very far away. Do you know how much time it requires for light to travel this distance? Only 8 minutes and 13 seconds. It would take about 8 hours and 20 minutes for light to pass through the planetary system: about 4,000 years to leap across our stellar system and more than 10 million years to traverse the distance to the farthest nebula that the telescope permits us to observe. And there are certainly other nebulæ still farther away, and probably millions and millions of stellar systems like ours evolving in the infinite space that we shall never be able to perceive.

Four hundred and ninety-three light *seconds!* Such is the distance from the earth to the sun. Ten million light *years!* Such is the greatest distance from the earth to the farthest nebula that we are able to discern. The comparison of these two numbers gives us an idea of the immensity of the space that this telescope can fathom. If that distance of 10 million light years represents a feeble part of the infinite, what is the size of the universe?

SPEED

Let us take the unit per hour as a base of speed. The average speed of a pedestrian is about 4 miles per hour. The maximum speed reached by a passenger express train is about 80 miles an hour. The most rapid airplane flies with a speed of 200 miles an hour; this is the maximum speed which can be attained by man. The utmost speed obtained by mechanical power does not exceed 2,400 miles per hour, which is the speed of a rifle bullet. The earth moves along its orbit with a speed of about 66 thousand miles an hour. The average speed of β rays, particles of radium which pass through an aluminum sheet of a few millionth of thickness, varies from 18,000 to 175,000 miles per second. The speed of α-rays of radium is about at 18,000 miles per second. The γ-rays of radium which can pass through a steel sheet of several inches thickness, have a speed of about 180,000 miles per second, or about 650 millions of miles per hour and the utmost speed which can be measured is that of light which is 186,000 miles per second or 670 million miles per hour. What shall we think of this tremendous speed of light when we compare it with our bullet, the speed of which does not exceed 2,400 miles per hour?

ENERGY

We shall take the horsepower as a unit of energy. One horsepower is the energy which lifts 550 pounds to a height of one foot in one second. One horsepower = 550 foot-pounds per second. The average energy of a man is about 1/10 of one hp. The most powerful locomotive develops 5,000 hp. The most powerful steam turbine in the world develops an energy of 46,000 kw. or about 60 thousands horsepower per unit. The steam engines of the largest battleship furnish 180,000 hp. The kinetic energy of a 15-inch shell produced by its speed at the exit of the gun is about 500,000 hp. The power developed by hydraulic turbines at Niagara Falls exceed 600,000 hp. The total power of Niagara Falls is estimated at about 6 millions hp. A steel sphere 3 feet in diameter revolving at a rate of 1,000 r.p.m. develops the enormous kinetic energy of about 1,600 hp. Applying the same calculations to the earth, the diameter of which is 12,700,000 meters, the kinetic energy produced by its rotation amounts to 300 million billions of billions of horsepower (300,000,000,000,000,000,000,000,000 hp.). The travel of the earth around its orbit produces the formidable energy of about 3 thousand billion billion billion horsepower. (3,000,000,000,000,000,000,000,000,000,000 hp.). The sun, which weighs 325,000 times as much as the earth and which is moving toward the "Constellation of Hercules" with a speed of 240 millions of kilometers per year (150 millions of miles per year) develops by his motion, the enormous power of 20 million billion billion billions of horsepower = (20,000,000,000,000,000,000,000,000,000,000,000 hp.). The sun alone possessing such an energy, what is the total power of our planetary system, and if this system, as previously stated, is only an infinitesimal speck in space, what must be the total energy of the universe!

CALORIFIC AND LUMINOUS POWER

The unit of heat is the calory. The calory is the quantity of heat necessary to raise 1 kg. of water 1° cent. of temperature. The mechanical equivalent of heat is equal

1 calory = 425 kg./m./s.

The sun, the temperature of which is about 7,500° Cent. develops a calorific power of 100 thousand billions of billions of calories per second. Our little earth absorbs only the 2,300 millionth part, that is to say 40 thousand billion calories each second, which is in itself a very respectable number.

The unit of luminous power is the candle. The luminous intensity of the sun is equal to 1,500 billion billion candles, which represent about 60 billion billion electric lamps of 25 candles each. The earth receives only the 2,300 millionth part of this gigantic light. What shall we think of the searchlight giving only 1 million of candles as compared with the sun, which itself is only a very small unit among the millions that stud the universe.

ORGANIC CORPUSCLES

The "Ciron," that small mite living in detritus and measuring 1 cubic millimeter or 0.000,064 cubic inch (the size of a sand grain), was in the good old days considered the smallest organism existing. Today the microscope detects an extraordinary world living in a space not larger than that of a mite; 0,000,064 cubic inch of tripoli is composed of more than 2 millions of fossil shells.

Pure water, colorless and odorless, contains about 150 billions of infusoria in a drop not larger than a mite. In observing this drop of water through a powerful microscope, giving an apparent diameter of 12 feet to this drop, you will be surprised to see the intensive life which reigns in such a small space. These corpuscles are so numerous that it would be impossible to insert the point of a pin in a space that is unoccupied: The little animalcules all touch one another, cross one another and devour one another to provide for their existence, and it is possible that there exist still smaller animalcules that we cannot detect with today's microscope. Vinegar which gives so much taste to salad contains a much more considerable number of such corpuscles. Some of the bacteria are so small that about 700 billions of them are necessary to make a gram, some of them give birth to about 16 millions of their species in less than 24 hours. A blood corpuscle, the diameter of which does not exceed 7/1000 of a millimeter (0.000,028 inch) contains not less than 3 billions 600 millions of organic particles. How about the mite if we compare it with these infinitely small animalcules? Nature is as complex in the infinitely small as in the infinitely great.

PHYSIOLOGICAL EFFECTS

The human ear is accustomed to perceive sounds, the number of which varies from 16 to 33,000 per second. The tone "A" has 435 vibrations per second. The deepest base tone "C" vibrates 62.25 times per second, and the highest soprano tone "C" has 1,044 vibrations per second. The highest tone that the human ear can perceive vibrates 33,000 times per second. If we hear sounds, the vibrations of which vary from 16 to 33,000 times per second, it is because our tympanum is in accordance with that number of vibrations, which is due purely to a physiological disposition. Suppose, for instance, that our ear was accustomed to detect sounds, the number of vibrations of which vary from 33,000 to 34 billions a second, all our musical instruments would be imperceptible to us. We would not hear their music at all, but would be able to hear electrical waves.

Let us, for a moment, consider human sight. Our eyes perceive light, the number of vibrations of which varies from 400 to 700 trillions per second. If our retina were more sensitive and permitted us to perceive vibrations varying between four and five billions of billions per second, we would be transported in a strange world. Our eyes would have a penetrative power similar to the X-rays. In this case all colors would disappear. Taking a walk in the street, we would meet ambulant skeletons. Passing through a forest, we would see no trees, but we would perceive the sap in thin strings rising slowly toward the leaves. With our X-ray eyes, let us go into a house. What shall we see? The windows will be opaque, the walls transparent. To be normal to our strange eyes, the windows should be made of wood or of iron sheet, the walls should be of glass; all the furniture, chairs, tables should be covered with a thin glaze to be seen. Our condition of living would be quite different from that to which we are accustomed.

TIME

Time like space and force is relative. Time has no limit. The second does not signify anything in itself, this is an absolutely arbitrary base which man has chosen as a time unit.

A second represents the 86400th part of the time taken by the earth to make a complete rotation about its axis, which is a day, and the latter is the 365th part of the time that the earth takes to accomplish a revolution around its orbit which is a year. The average life of a man is about 70 years, which is only 2,200 million seconds. Certain bacteria do not live longer than a fraction of a second. A butterfly lives a few hours. Some scientists suppose that the human life appeared on the earth some tens of thousand years ago, and that organic life appeared about 250 million years ago. The primitive epoch during which the superficial part of the earth has been solidified, is supposed to date back some 500 million years. As the data of appearance of human life and organic life on the earth cannot be verified, the figures above mentioned cannot be taken as correct. If the first foundations of terrestrial crust date back about 500 million years, probably some billions of billions of centuries have elapsed since the planet was detached from the solar nebula, and if that is so, how long ago was the solar nebula founded? Mystery! Time is without limit!

ATOM AND INTER-ATOMIC ENERGY

The number of hydrogen atoms contained in a 1 cubic millimeter (1/15625 cubic inch) is about 36 millions of billions (36,-000,000,000,000,000) and as each atom is composed of 2,000 electrons this makes 72 billions of billions of electron particles contained in such a small space. A pin head contains the enormous number of 8 thousand billion billion atoms (8,000,-000,000,000,000,000,000). Let us try to gain some idea of this phenomenal number. Suppose that an atom is represented by a little cube measuring an inch on each side, if we pile these together, we shall have a cube measuring 310 miles on each side. If each atom of this pin head is composed of 1,000 electrons, you can imagine the enormous number of inter-atomic particles contained in the one hundredth part of a gram of metal (1 metric gram is the twentieth part of an ounce).

The kinetic inter-atomic energy produced by the "dissociation" of matter is the work furnished by the speed of the dissociating electric particles contained in the matter. Suppose that this particle moves at an average rate of 62 miles per second, the dissociation of a metric gram would furnish a work of 6 billions 800 millions horsepower (6,800,000,000 hp.). But as the dissociation of matter is exceedingly slow, it would take more than 300,000 million years to liberate all particles, supposing that the dissociation takes place at a rate of one billion particles per second. So, you see, the power liberated in one second would be very small, about $\frac{1}{10}$ thousand of a millionth of a horsepower in the time unit. Let us suppose that this power of 6,800,000,000 horsepower be liberated in one second, this quantity of energy will be sufficient to operate a 500-ton freight train over a distance equal to four times the circumference of the earth. To cover this distance it would be necessary to burn 3 thousand tons of coal which at $10 a ton will cost $30,000. This would be the value of inter-atomic energy contained in one gram of metal if it could be liberated in one second. A sphere 3 feet in diameter possesses an inter-atomic power of 20 millions of billions of horsepower. If we apply the same calculation to our sun, the weight of which is 1,800,000,000,000,000,000,000,000,000 tons the inter-atomic energy produced by its dissociation would yield an inconceivable amount of power. Since the sun is but a spark in the stellar system imagine, if you can, what must be the total inter-atomic energy of the universe!

WEIGHT

Let us take the metric gram which is the 28th part of one ounce as our unit of weight. "A fraction of a milligram

(1/28000 ounce) of radium salt, emitting, without intermission for years and years, some billions of particles each second," said Gustave Le Bon, "will not lose enough of its weight to be measured by an ordinary weighing scale."

Curie's electroscope detects the presence of one thousandth of a billionth of a gram of radium. By the sense of smell we are able to detect a hundredth of a billionth of a gram of iodoform. The spectroscope detects the presence of 3 billionths of a gram of ordinary salt. A liter of clear water weighs 1 kg. or 2.2 pounds. The average weight of a man is about 75 kg. A sphere of metal 3 feet in diameter weighs about 3,200 kgs. The earth weighs 5,500 billion billion tons (5,500,-000,000,000,000,000,000 tons). The sun, which weighs 325,000 times more than the earth, would tip the scales at 1,800,-000,-000,000,000,000,000,000,000 tons. The total weight of all planets does not exceed the 700th part of the weight of the sun.

SUMMARY

The most tenuous corpuscle that man has determined by experimental and mathematical deduction is the positive electron which is the smallest particle of matter. The electron, the diameter of which is 10^{-16} cent. has a volume of 0.000,000,-000,000,000,000,000,000,000,000,000,000,000,000,001 cubic millimeter (1 cubic millimeter $= \frac{1}{15625}$ cubic inch). The atom has a volume of 0.000,000,000,000,000,000,001 cubic millimeter. Let us try to compare these two numbers with a small ball one centimeter in diameter (1 cent. $= \frac{1}{2.5}$ inch). Suppose the atom is represented by the earth, our electron would have a diameter of about 5 inches and the small ball would take the formidable proportion of a sphere whose diameter would measure about 50 light days, that is to say about 140 times the diameter of Neptune's orbit. In this case the diameter of the ball will have the proportion of 130,000,000,000,000 meters. Judge now the smallness of the electron! The volume of the earth is 1,000 billion cubic kilometers. The volume of the sun is more than one billion billion cubic kilometers. Suppose our stellar system were of spherical form with a diameter of 4,000 light years, the space occupied by this sphere would attain the enormous number of 32,000,000,000,000,000,000,000,000,000,000,-000,000,000,000,000,000 km^3. Now, let us consider the farthest nebula that we can detect, and which is estimated to be at 10 million light years, from us. Suppose that were the radius of a sphere embracing all that it is possible to see. The space occupied by this sphere would have the enormous value of a cubic kilometer multiplied by 5 followed by a trail of 60 zeros. If our stlelar system was reduced to the volume of the earth and the space above considered were reduced in the same proportion, its diameter would be nearly equal to that of Neptune's orbit.

Now, that you have some figures before you, try to imagine the dimensions of the electron, try to conceive the space that we are able to detect with the telescope. And let us finally establish the relation between these two extremes, which gives the most formidable number that man can imagine which is number 5 followed by 123 zeros. Inconceivable, isn't it? However this is not yet the limit! The enormous space that we are able to detect with powerful telescopes which is infinitely great relative to the infinitely small electron represents only a small part of the infinite space of the universe. The universe is infinite! The universe contains an infinite number of bodies which appear, evolve and disappear, followed by other forms which again appear, evolve and disappear, and so forth, accomplishing infinitely the same cycle in the infinite space through infinite time.

The Smallest Animal in Existence

An Account of the Results of Some Recent Studies of the Minutest Creature in the World

By Leon Augustus Hausman, Ph.D.

IN every wayside ditch and watering trough, in pools, streams, rivers, lakes, seas, and oceans, in fact, in all waters on the surface of the earth there exists a vast host of animal forms, invisible to the unaided eye, known as the protozoa. The interest which attaches to these minute forms is related to their meager size, primitive structure, and to the probable fact that these forms represent the first embodiment of animal life which arose on our earth.

We are accustomed to think of animal bodies as fairly complex structures, *i.e.*, composed of various tissues and organs. The different organs in a complex animal body are made up of tissues, and these, in turn, are composed of cells, tiny units of structure, invisible, for the most part, to the naked eye, and comparable to the bricks which go to make up a building.

The protozoan body can hardly be said to be composed of cells, in the plural, for the entire body is itself but a single one of these unitary animal parts. For this reason the protozoa are said to be unicellular.

A large majority of the protozoa lie below the range of vision of the human eye. Indeed but three or four species only can be discerned without the aid of the microscope, and these only when placed on a glass slip and held in strong light against a black background. Even these forms are extremely minute, the largest of them, known as *Dileptus gigas*, being only about 1/60 of an inch in length! Most of the species lie below 1/254 of an inch along their longest dimension.

It is to this group of protozoa, or first animals, for that is what their Greek name means, that there is found what is, up to the present state of our knowledge, the smallest animal form in existence. This Lilliputian of the animal world is commonly but 1/5,000 of an inch in diameter, and the writer has found many indiviuals which measured but 1/12,700 of an inch! A photograph of this creature, which rejoices in (or more probably is happily ignorant of) the name of *Pleuromonas jaculans*, a name signifying the one-sided darting creature, is shown in Fig. 2. In form, the body is usually kidney-shaped, with a definite, thin cuticle investing the whole, and almost transparent. Within the body there can sometimes be distinguished minute granules. From the shallow depression in one side of the body there arise two long filamentous appendages, known as flagella, or whips. It is by lashing these from side to side, or up and down, that the creature makes its irregular progress through the water, or possibly draws food material toward the base of the whips. Mouth there seems to be none, but since the animal often lies with its concave side closely pressed up against a mass of bacteria, or putrescing material, it may be supposed that particles of food adhere to the rather viscous protoplasm (cell substance) and are withdrawn into it. This is known to be the manner of feeding of several other of the protozoa, closely related to the *Pleuromonas*.

In making its progress through the water, *Pleuromonas* moves with a series of rapid darts and jerks, and then comes suddenly to rest. But even its resting periods are not periods of entire immobility, for all minute particles, suspended in a liquid, exhibit a rapid vibratory or quivering movement, which is caused by the incessant bombardment of molecules of the surrounding liquid. This movement is known as the Brownian Movement (or pedesis) from its discoverer. All particles suspended in a liquid like water, show this movement, if their

FIG. 1. A GROUP OF PLEUROMONAS IN CHARACTERISTIC ATTITUDE

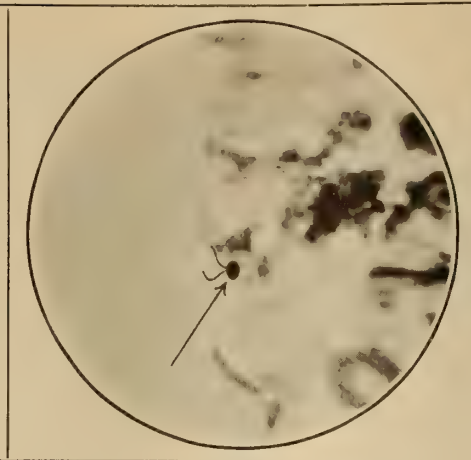


FIG. 2. A PLEUROMONAS LYING AMID DEBRIS—ENORMOUSLY MAGNIFIED

FIG. 3. ELVIREA CIONAE, A CLOSE RELATIVE OF PLEUROMONAS

diameters are less than 1/500 of an inch. The less the diameter of any particle, the more pronounced its agitation. Hence part of the characteristic motion of our little *Pleuromonas* is an entirely involuntary one.

Pleuromonas, together with many of its relatives of scarcely larger size, inhabits pools and ditches wherein plant material is decomposing. The presence of putrefactive bacteria seems to be a *sine qua non* of its existence.

How great a range of magnitude and complexity exists in the animal world is strikingly presented to the mind when one considers the latitude which separates such an animal as the *pleuromonas* from some of the earth's animal Titans. The *Gigantosaurus*, for example, is described by an English scientist, Prof. Ray Lankester, as totaling 120 feet from nose to tail! This is a length over 18 million times greater than the smallest of the *Pleuromonas!* Another interesting comparison is the relative weights of the *Pleuromonas*, and one of our modern mammals, the heaviest creature which ever lived, the great Sibbald's whale (*Balaenoptera sibbaldii*). This titanic creature is estimated to weigh not less than 150 tons! From computations made by the writer, the weight of one of the smallest specimens of *Pleuromonas* would lie in the neighborhood of one one-hundred thousandth gram. Thus relations in weight between the animals that lie at the very antipodes of avoirdupois is as 1 to 14 trillion!

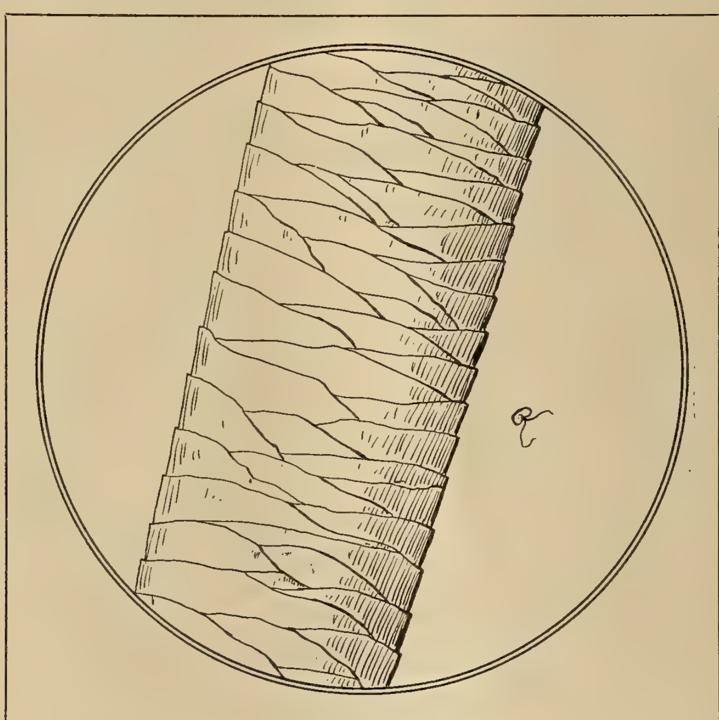


FIG. 4. PLEUROMONAS JACULANS, COMPARED WITH AN AVERAGE HUMAN HAIR

It is not alone because of our interest in the zoölogically curious that scientists are lead to make studies of the *pleuromonas* and of its near relatives, the *Mastigophora*, or whip-bearers, but because the study of these minute forms of life leads to a clearer conception of what life itself is; how the cell, which is the unit of all life, plant as well as animal, behaves, and what it is capable of when existing alone. Furthermore the economic importance of these minute creatures, like that of their equally minute plant relatives, the bacteria is very great. Areas of water containing *pleuromonas* are often colored a milky hue by the vast numbers of individuals present. Each of these countless millions of animals is engaged, and busily so, in transforming what would otherwise be dangerous decaying substance, into animal protoplasm, by feeding. These minute creatures are, then, scavengers, and the work which they accomplish together may be of considerable importance. For they convert putrescence into a form in which it serves as food for larger protozoa and tiny crustaceans, and thus they perform a real service in keeping in our waters a supply of food for the larger forms, such as fishes.

VOICE IN YOUNG AND ADULT BIRDS

SOME very curious studies have been made by two German ornithologists named Stadler and Schmitt, regarding a change of voice in certain kinds of birds, from youthful to adult tones. While this is lacking in most birds it is so marked in others that it may be fairly compared with the so-called change of voice in boys. This marked transformation is found in young buzzards among which the sounds uttered by the young are about an octave higher than those of the older birds. In certain owls the call of the young is even as much as 1½ and 2 octaves higher. In the young domestic duck and in some owls the tones are ¼ higher than the voice of the father.

Young moor larks and finches exhibit an actual break in the voice—that of the fledglings being harsh and unmusical. In young domestic fowls this break or change is very marked.

It often happens indeed that after the birds have reached a certain stage in their development both voices may be heard almost at the same time in the same individual. Then the young voice is silent and the adult voice gets the upper hand.

In some birds, which have a youthful plumage which differs from that of the adult, there seems to be a certain connection between the change in voice and in the coloring of the feathers—this is certainly the case in the silver gull.—From *Kosmos* (Berlin).

The Sterlingbush Calcite Cave*

Difficult Problems Solved in Reconstructing the Cave in the New York State Museum

By Noah T. Clarke

IT may be of interest to museum workers with their many problems in common, to know something of the story of the remarkable grotto now housed in the State Museum.

Several years ago in a quarry at Sterlingbush, Lewis County, N. Y., an opening of some 4 feet in diameter was revealed after blasting. This opening proved to be a puncture in the wall of a grotto which broadened out to 10 feet in width and 5 feet in height and extended back for 20 feet to a narrow vault of 4 feet in diameter, continuing on a gradual slope downward for 20 feet more and terminating in an inaccessible and almost perpendicular crevice. Realizing that in the course of quarrying operations the crystal contents of this grotto must be destroyed, it was decided to remove them to a place of permanence where the public might have access to an exhibit as near like the original as practicable. On account of the size of the crystals the task of removal and safe shipment of some 14 tons was a tremendous undertaking. Some of them weighed as much as a thousand pounds and each, whether large or small, was a perfect geometric development of calcium carbonate delicately colored by manganese to an amethyst in reflected light and pink in transmitted light.

*From the Report of the Director of the New York State Museum (1918).

The problem of reconstruction was ahead and careful detailed study of the project had to be assumed and worked out by those skilled in many arts. A blind closet about 8 feet square beneath an arch in the mineral hall seemed a likely place for such an exhibit but the difficulty in this was to obtain in such a small space the depth required by the original cave. After much experiment it was found that by placing upright a plate glass mirror 18 by 24 inches at the farthest left-hand corner of the closet and at an angle of 46° to the observer and also a second mirror 14 by 34 inches, tipped back slightly and hidden from view in a proposed recess on the right directly opposite the first mirror, we could produce an apparent depth of 25 feet and a gradual slope down to a narrow passage, as in the original. With this arrangement the spectator could not see his own image or the ordinary visitor detect a mirror.

The iron frame work which was to support the weight of the crystals was built of 1¼ inch angle iron and, in order to relieve the great strain on the museum floor, suspended from a roof girder by a seven-eighths inch iron rod with a turnbuckle.

The form of this frame was determined by making a full-size ground plan of the closet and by bending thin strips of wood into the shape of the intended iron ribs. There were

THE STERLINGBUSH CALCITE CAVE AS RECONSTRUCTED IN THE STATE MUSEUM AT ALBANY, NEW YORK

fifteen of these ribs which met at the center of the roof and were bolted in place to a large circular iron plate. The general shape of the completed framework was that of an irregular dome with a false floor built of 2-inch angle iron 20 inches above that the museum floor. The object of this was to place the visitor in a more intimate relation to the exhibit by bringing the crystals into greater prominence. An opening 2½ feet square was provided in the front of the iron work to allow for a window for the observer.

Our attention was devoted for nearly two months to preparing the crystals for exhibit and working out a method to fasten them to the walls and roof. There was a secondary or stalactitic formation over many of the crystals which was removed by applying dilute hydrochloric acid with a jeweler's brush, always exercising great care in order to confine the acid to the particular spots where there was crust, so as not to injure the fine sharpness of the angles and the exposed faces of the clear crystals.

To suspend calcite in large and bulky crystals from the ceiling and in every conceivable position at any angle was the proposition now before us. If one has had the experience of drilling a fine calcite crystal and had it fly into a half dozen pieces he can imagine the discouragement of having several hundred crystals before him to be drilled accurately, some to have three and four holes each. This was exactly the problem. We devised an individual clamp which would have held the weight of the crystal but to make a special clamp for each separate specimen would have been impracticable on account of the area of crystal faces concealed and the expense and time required to make them. Further experimenting with flat drills nine thirty-seconds of an inch and seven thirty-seconds of an inch diameter of Stubb's English steel, hardened in water and drawn to a straw color, used in a lathe turning at a slow speed of about 400 revolutions a minute, proved to be a successful method to obtain results. This way we were able to obtain a steady motion and apply a gradual and even pressure, so essential in overcoming the difficulty of boring through many cleavage planes which were always a constant source of trouble. With this procedure, out of all the lot, just two crystals failed us. Thin slabs composed of clusters of small crystals were drilled entirely through. An iron bolt with a loop at one end was fastened in these holes by means of a nut and washer on both the face and back of the specimen. The exposed nut on the face of these clusters was easily hidden by matching a small crystal over it. The larger specimens, however, were bored for a depth of only 2 inches and in each hole was set a 1⅞ inch screw eye; the heaviest crystals necessitating special heavy irons of the same shape. By pouring melted sulphur in the hole and immediately plunging into it a red hot screw eye, we had a means of support, when cold, by which the crystals could be wired in any position to the iron framework. Many times the distance between the iron ribs was too great and necessitated spanning these spaces with three-fourths inch or 1¼ inch band iron.

The actual placing in position of the crystals was started at the deepest point, which was around the mirror. Small areas of the frame were covered as needed with galvanized iron wire screen of one-fourth inch mesh. After a crystal had been securely wired to the framework, a combination of cheesecloth and plaster woven over the wires and frame between the screen and crystal held it permanently in the exact position desired. This same process was continued gradually around the sides and roof to the window.

Each time a crystal was placed there were three points to consider: Did it fit exactly to the one next to it? Were the best crystal faces seen, not only looking directly at it but in each of the two mirrors? Was it possible to place behind it an electric light which could not be seen from three sides? These questions arose simultaneously nearly every time and the solution was simply the answer given by trying out each of them.

The construction of the floor was the last and comparatively the easiest operation. Two-inch spruce planking was laid over the floor girders to carry this great weight as the largest crystals of the original cave were found on the bottom, many of them entirely free on all sides and apparently with no surface of attachment. For this reason it was not necessary to place these so close together, which gave a good deal of leeway for electric lights with shades.

We have carefully shaded a system of twenty-one lights ranging from 10 to 60 watt, which have been placed behind the most highly colored crystals. The astonishing effect of glowing soft colors by so transmitting the light could not be achieved in any other way, and although this condition could not be found in nature, the aid of a little intensified light certainly brings out and emphasizes the exquisite beauty which would otherwise lie dormant or be lost.

LIVING PLANTS IN SOLID ROCK

IT seems almost incredible that living vegetation should have been found thriving in what to all outward appearances is solid rock. Yet this has been proved to be an actual fact. A German scientist, Diels, making a study of the algæ which grow within the crevices of the Dolomites of the Southern Tyrol, discovered upon splitting open the hard, living rock having no crevice visible to the eye through which light, air, or moisture might penetrate, thriving layers of algæ arranged beneath the surface. "Almost every blow of the hammer," writes Herr Diels, "revealed such vegetation, which is entirely invisible from without. The zone of growth varies in depth from 4 mm. to 8 mm. where the surface of the rock above is bare. When the surface is covered, however, with vegetation, the stone-dwelling algæ are found nearer the surface, at from 1 mm. to 2 mm. in depth, since modest as their wants may be they require a certain degree of light to enable them to grow."

These stone-dwelling algæ are of more than one kind and are arranged in zones or bands according to the amount of light which they require. Humble as these plants are they are of considerable importance in the scheme of things, since they assist the other forces of nature, such as frost, earthquakes, and changes of temperature, to break up the living rock and change it into fertile soil for higher forms of vegetation.—Abstracted from *Naturwissenschaftliche Umschau d. Chem. Ztg.*, for November, 1920.

STUDYING GLACIERS WITH THE STEREOSCOPE

AT a recent meeting of the French Academy of Sciences (March 7, 1921) an account was given by M. P. L. Lercanton with respect to his study of glaciers by means of stereoscopic views. It is not always possible to place sign posts at the front end of the glacier so as to study the rate of its advance, since in many cases this would require too much time and trouble while in others it might be attended with danger. A direct comparison of a series of successive photographs does not always suffice to show the slighter modifications in the form of the glacier. M. Mercanton consequently conceived the idea of making use of the stereoscope to detect these slight variations. The stereoscope has been used in a similar manner for a long time to detect forgeries or alterations in bank notes as well as by astronomers in searching for comets and small planets.

As applied to glaciers the process is as follows: From the same position and with the same camera two photographs of the front of the glacier are taken, preferably with an azimuth normal to the presumed direction of the variation and at a given interval as of a year, for example. When the two proofs taken at the different times are examined through a stereoscope those areas of the glacier which have been modified will be shown in relief on the portions of the photograph which correspond to motionless objects such as the sky, rocks, etc.

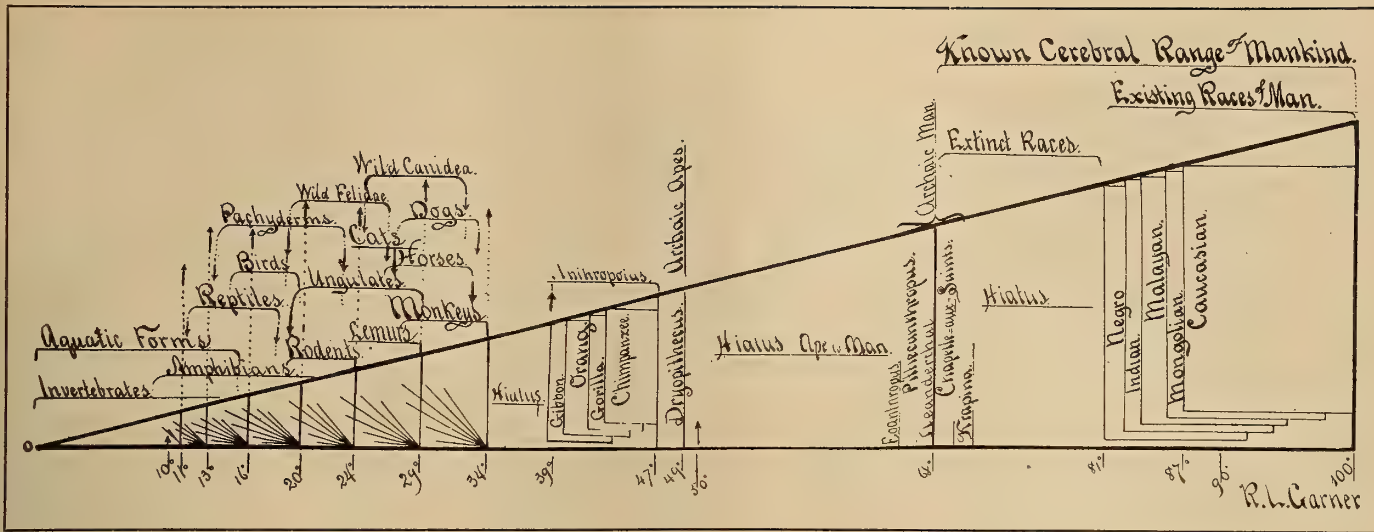


FIG. 1. CHART OF COMPARATIVE INTELLIGENCE OF ANIMALS FROM MAN TO AMPHIBIANS

The Animal Mind

The Comparative Intelligence of Animals

By the late Dr. R. L. Garner

IT is difficult to find a common unit of measure by which to determine with precision the various horizons of the minds of different species of animals. Hitherto it has been chiefly a matter of guesswork, and most people let their fondness for a certain kind of animal bias their judgment. Upon surveying the whole range of animal intelligence, it is apparent that there are many levels, and by comparison it is possible to formulate a system by which they may be graded. The process of accomplishing this is by a study of the environments of a race, its physical development, its mode of life, and by interpreting the actions of its members and the motives which prompt them. In the animal kingdom as a whole there is a wide scope of intelligence, ranging from protozoa to man, in which certain obvious divisions must be made according to their disparity. Probably all minds are the same in quality and compass, and the degrees of difference constitute the problem to be solved.

At a glance it is evident that those forms of life which live under the most restricted conditions are the aquatic and amphibian forms. Shut in by the surrounding waters, aquatic animals have a poor medium through which to receive sense impressions. The element in which they live not only lessens their opportunities of experience, but likewise lessens their need for knowledge of their surroundings. These impressions are, therefore, comparatively few in number and dull in nature, and the resultant development of senses correspondingly less, which places aquatic forms far down the scale of comparative intelligence. For the same reasons amphibians are only a trifle higher in mental horizon.

The advantages of sense development through experience are chiefly with the terrestrial forms of life. Among these the most conspicuous divisions are between those of nocturnal and those of diurnal habits, of which the former suffer in much the same way as the aquatics in restriction of experience, although, obviously, to a much less extent. Diurnal animals, spending their waking hours as they do in the clear light of day, have the greatest opportunities for acquiring new and distinct impressions, and are logically those whose mental attainments stand the highest because of the advantages of frequent use and its consequent development. Aquatic and nocturnal animals receive a measure of protection from the media which restrict their perception of exterior things, and, therefore, have less need for alertness, skill and strategy as means of self-preservation. Many of them tend to develop but sluggish senses and often grow large bodies with comparatively small brains. The *carnivors*, the *pachyderms*, reptiles and lower forms, most of which lead isolated lives and therefore cultivate but little social intimacy with their kind, while their optics are more acute than those of diurnal animals, are yet far below them in the scale of intelligence. Their mental horizon in comparison to that of diurnal animals is as the distance and distinctness of their vision in the surrounding darkness to that of the diurnal animals in the light of day. The *ungulates*, or hoofed animals, are of mixed habits and bear nearly the same relation between the nocturnal and diurnal animals that the amphibians do to aquatic and terrestrial forms. They are inclined, however, to live in herds, instead of family groups, and have only the rudiments of social life. They are strictly herbivorous. They are, perhaps, exposed to more danger from enemies than the carnivorous, but because they band together in greater numbers, their faculties of observation and alertness are less taxed, and their chances of survival upon being attacked are proportionately greater.

As the basis of comparison of animal intelligence, man as the highest type occupies the foreground of a perspective (see Fig. 1) of 100 units, the vanishing point of which is at zero, where protozoan life begins. Inasmuch as we find in man the most active and efficient faculties of mind, it is logical to assume that he possesses the means and qualities which promote the growth and development of all psychic activities. It also seems clear that *those animals which are most highly specialized and, therefore, most resemble man in their physical development likewise most nearly approach his mental horizon.* In the lines of investigation so far pursued, man obviously occupies the highest level, and it appears equally clear that other genera follow him in the same order and degree in their mental status and possess the greatest individual possibilities for advance beyond the normal stage of their kind, and in pursuing further the manifestations of these elusory forces, the validity of the foregoing premises become more and more evident.

According to these it would follow that the manlike apes possess higher mental powers than those of any other group of animals below man, and investigation amply substantiates this conclusion. Through twenty-five years of methodic study of animal life this fact has been borne in upon the writer by such force of evidence, that what was once a theory has long since become a conviction, and the same conclusion is being

reached by all scientists who have devoted sufficient time to the study of the subject with due respect to the weight and cogency of the evidence.

Of the ape group the highest level is occupied by the chimpanzee. This has been clearly demonstrated by the education of certain specimens of this genus. By means of such specimens, educated with laborious care to obtain the most reliable results—differentiating always between *education* and *training*—the writer has demonstrated that the chimpanzee mind is endowed with many powers formerly accorded to man alone. Among these, the perception of abstract values and their relation requires the highest form of mental capacity, and surely constitutes the crucial test of intelligence. Scientists had hitherto believed this power to be entirely above the range of any animal mentality. Yet a young chimpanzee learned to distinguish concrete geometrical forms and pick them out by word of command, in blocks of three dimensions, or upon a plane surface in relief or countersunk. The little ape learned by name and to distinguish between five different colors regardless of the forms they covered.

The crowning accomplishment which bore down all opposition was the ability to count any collection of small objects, such as beads, grapes, nuts, jackstones, or other things which she could handle easily. The chimpanzee did not guess at the numbers, but drew them from a pile, one by one, and counted them in any order up to four, obviously appreciating the numerical value of each number in exactly the same way as a human being does. This was accomplished in four months of teaching, beginning when the animal was one year old. During this period it was found that the difficulty of learning for the chimpanzee mind is not measured simply by the addition of the number of things to be learned. To add digit values to her repertory, for example, the difficulty incident to the process was equivalent to the powers of the number of distinct concepts. In other words, each single thing taught being regarded as one unit of difficulty, to teach her to count *three* was not simply the sum of three units of difficulty, but was *nine* times as difficult, or the square of the number of concepts.

$C + C + C = 3(3D)$

$C =$ concept.

$D =$ difficulty unit.

To cite another case, it was *four* times as difficult to teach the little ape to grasp the idea of *white cube* as it was to teach her the concept of either *white* or *cube*. To teach the idea of *big red cube* was *nine* times as difficult as to teach her any one of the three concepts alone. The difficulty of teaching the chimpanzee mind to perceive and appreciate abstract values advances thus, one- four- nine- and sixteen-fold. Compared with the simple addition, or thereabouts, of the human brain, this shows the relative capacity of the two types of mind.

No other genus below the human has ever accomplished anything to be compared with this chimpanzee. Other specimens of the same genus have displayed unmistakable ability in similar ways, which leads the writer to believe this one to be a fair standard of chimpanzee intelligence. Without betraying any trade secrets, I feel justified in stating here that the horses, dogs and other animals that are alleged to have learned to count, or select certain figures by word of command, are pure and simple products of expert fakery, so far as real education is concerned. I have been associated for many years with the best animal trainers in the profession, and most of them have kept no secrets from me; but it is no injustice to them to say that scientific methods of *teaching* and their methods of *training* are as different as the respective ends sought, the one being strictly scientific—and accurate—the other strictly commercial, without other considerations.

Investigation thus demonstrates that the chimpanzee is next to man in mental endowments, and it will be seen that this genus of ape most resembles him in physical structure, also. The general physical resemblance of the chimpanzee to man is too obvious and too well known to dwell upon here; but in skeletal formation the similarity is still greater. In fact in only two sections does the skeleton of a chimpanzee differ in structure from that of man, viz., in the *sacrum* and the *sternum*, and neither of these discrepancies is very great. With these comparatively trifling exceptions, the skeletons of man and the chimpanzee may be truly said to be exact counterparts of each other, having the same number of bones, of the same general model, arranged in the same order, articulated in the same manner, and performing the same functions. In other words, the corresponding bone in each is the same in design and purposes. The gorilla, which has been found to be next to the chimpanzee in mentality, possesses a skeleton which is a counterpart of that of the chimpanzee in its general structure, save for the cranial ridges in the skull of the adult male. In some respects the gorilla skeleton is slightly less like that of man than the chimpanzee. Somewhat less like man is the ourang-outang both in skeleton and soft anatomy; and his mental possibilities are correspondingly less than those of the gorilla. The gibbon is still more removed from man in these points. His mentality appears to be of a lower type than that of the ourang-outang.

As investigation is carried farther the physical points in common and the variations corresponding approximately to their inferiority, multiply accordingly. Many persons shrink from the thought of man being allied to the ape because of the hirsute of the latter; and yet if a square inch of the skin of an ape be compared under the microscope with the corresponding area on the surface of the human skin, there will be found approximately the same number of hairs on each. Man has probably lost the heavy hair on his body primitive through ages of wearing clothes, just as he has lost the prehensile use of his foot probably from wearing shoes. It has even been found that apes are subject to many diseases of man to which other animals appear to be immune.

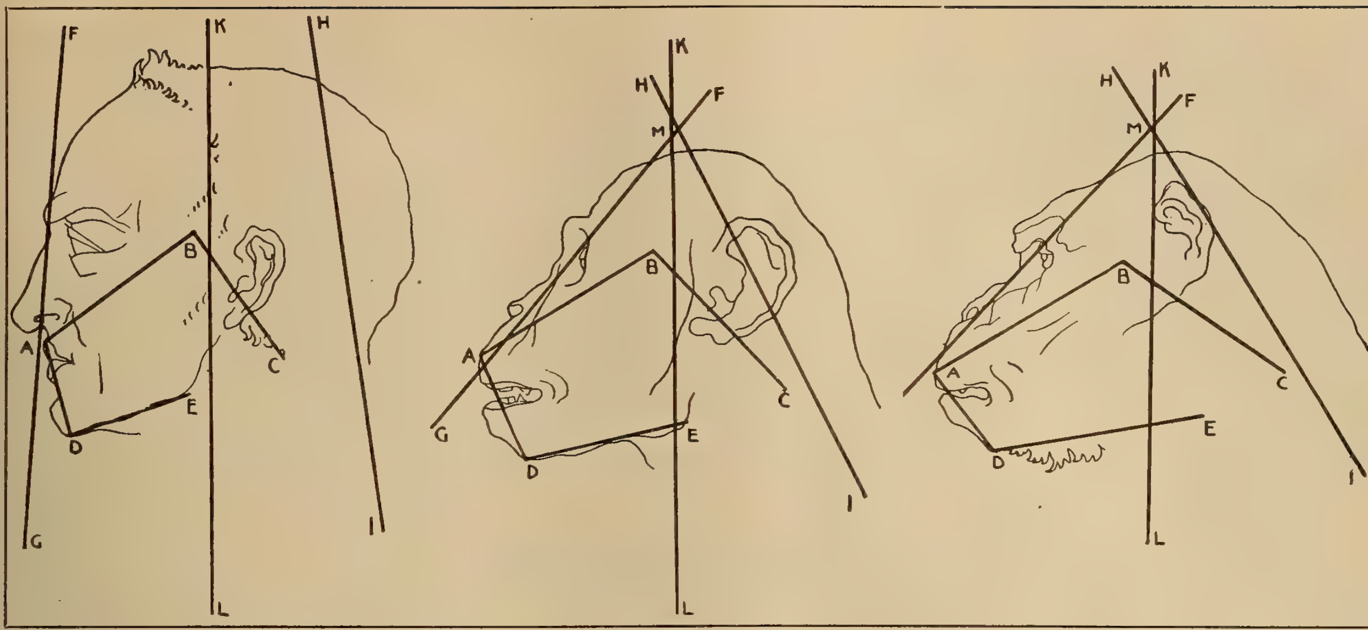
Dr. Reichert of the University of Pennsylvania has performed a vast series of experiments which demonstrate that the blood crystals of the chimpanzee and the gorilla are very much more like those of a human being than they are like any species of monkey known. The chief difference between the human and the ape crystals is a greater obtuseness of certain angles. The axes are almost the same, the geometrical forms are the same, with an equal number of similar facets and angles, and arranged in the same order. In fact they are of the same system.

The clavical, or collar bone, is more developed in apes than in other simians. In the lower species it becomes more and more primitive in form and less uniformly articulated in inverse proportion to the habit of erecting the body either habitually or occasionally, while in lower orders of animals it is hardly articulated at all, being quite rudimentary and probably useless.

In this way the physical resemblance to man may be traced with variations through the entire perspective of animal life, and it would be found to hold essentially true in relation to comparative intelligence.

The diet is another reliable index of the mental horizon of any genus of animals. Those forms which have the most varied diet and which are the most fastidious in selecting and preparing their food, are found to be more highly developed in mentality than those of more simple diet and less discrimination of taste. Multivorous man conforms to this rule even in the different races of his genus. In search of variety of food, animals necessarily range through a wider field of experience, expose themselves to more varied conditions, incur more dangers, which demand greater exercise of their wits to avoid and thus they get a more or less intensive mental training.

It is also an interesting sidelight upon the question of the search for food in relation to animal intelligence, that those animals which dwell in the vicinity of human beings, pitting their faculties against those of man, are mentally superior



FIGS. 2 TO 4. CRANIO-FACIAL ANGLE (*A B C*), GNATHIC ANGLE (*A D E*), FACIAL PLANE (*F G*) AND CERVICAL AXIS (*H I*) OF MAN, COMPARED WITH CHIMPANZEE (*CENTER*) AND LOWER ORDERS OF MONKEYS (*RIGHT*)

to any genus or species that dwells habitually in the sequestered depths of the jungle. Among the anthropoid apes, the chimpanzee has, perhaps, the most varied dietary of any other race, and is about the most fastidious in his choice of food and his manner of eating it. He makes his habitat in the purlieus of human habitations, and much of his food is the fruit of man's toil, which the ape procures by stealth. In company with his family, he makes frequent raids on the gardens and plantations of men, employing tactics which would do credit to the wits of prowling schoolboys intent upon similar adventures. They take narrow chances, often with surprising success. The gorilla also is an adept in this art. His dietary, however, is less varied than that of the chimpanzee. He leads a more retired life, seeking the inaccessible places in the forest for his nightly bivouac, while the chimpanzee often builds his bed in a tree within a few hundred yards of a village, relying upon his own shrewdness to escape harm in this rather dangerous locality. The chimpanzee actually seems to like the proximity of human beings. The ourang-outang, next to the gorilla in mental endowments, takes still fewer chances in procuring his food, lives upon a less varied diet, depends more upon the wild products of the forests, and is more easily satisfied with what he obtains. The gibbon, last and lowest of the ape group, is much more addicted to arboreal habits, is more limited in his dietary and more timid in procuring it. He is much less fastidious in his choice, and comes less frequently in contact with man. In descending the scale of the monkey species, their horizons of mind descend in about the same degrees as they lessen the variety of their diet and their proximity to the dwellings of man. Below the monkeys the same rule holds good of the lemurs, which gradually merge into the *procynors*, including raccoons, civets, etc., which are allied in one direction with the *canidae* and in the other with the rodents.

In following out certain physical developments as coordinates of other faculties it appears that the movements of the digits also coincide with the mental development of all orders and genera. Man possesses some twenty-seven possible movements; the chimpanzee, twenty-three; other apes, twenty-one; monkeys, nineteen; lemurs, eleven; and so on down the scale to the reptiles, with only two, simply those of opening and closing the digits. The rodents, however, do not appear to conform strictly to this law, and in this may be the exception which is supposed to prove a rule, although in other ways they conform to the place to which they are assigned in the scale of nature, as shown in the diagram.

To man the use of the thumb is highly important, and to the ape only a little less so; but as we descend the scale it becomes more and more limited in its use and arrested or atrophied in development until, in forms below the lemurs it becomes a mere rudiment, or "dewclaw." In a few species of monkeys, however (usually of low levels) and prosimians, the thumb is entirely absent. In the *ungulates* it is absent, having been absorbed into the anchylosed carpal and tarsal bones.

The erect carriage of man is, undoubtedly, the result of slow development through the ages. This tendency toward the erect habit in the apes keeps pace with the development of intelligence along the scale of animal life. although it appears at a point above the stage reached by other genera. Through the whole range of simian races this coordination is traceable, although the close alliance of different species of monkeys makes it difficult to discern their exact relative standards of mentality.

In conjunction with this tendency is that of the glottic plane (or plane of the vocal cords) which, beginning with reptiles, occupies a position of approximately forty-five degrees from the axis of the larynx, tends toward the horizontal as we ascend the scale until in the apes it is approaching the horizontal, and in man it is still nearer to that position. The gamut of sounds, or scope of vocal products controlled by the glottis, undergoes similar variations. From man, whose gamut is the most varied of all animals, it is found that the chimpanzee has the most varied gamut of the lower animals, followed in order by the gorilla, gibbon and monkeys. The ourang-outang is possibly an exception. Continuing on down the scale, ultimately ending in the reptilian forms, we find the vocal powers more and more restricted in scope and degraded in quality, until in the lowest reptiles, they are lost in a mere hiss.

This scale of relative variety in gamut is of special importance here, inasmuch as it relates directly to the brain and its higher functions. Vocal sounds are, by their very nature, vehicles of expression, conveying definite concepts. A vocal sound emitted by an animal may or may not be intelligible to the hearer, but its source is not a vacuum, so to speak. In animal economy it is a de facto means of communication. The apes and monkeys have sounds which to their own species stand for ideas. Primitive wants and oft-repeated situation—each has its particular sound or word, which symbolizes it. Hunger, fear, love, aversion, danger, anger—all have their vocal symbols, many of which through years of

research the writer has become familiar with in several different simian and anthropoidal species. But as the animal brain is less and less complex, as we descend the scale, the reactions likewise become less and less complex, and the expression thereof becomes more and more primitive. Nature does not equip an animal with a faculty in a highly developed form unless it has a need for it in proportion to its complexity.

This brings us to one of the most interesting phases of the study of comparative intelligence of animals, and that is the *gnathic index*. In general the development of the chin of an animal is an index of the mental horizon of his genus. In the higher type of animals, such as man, the complexity of his being allows wide field of individual differences which are not possible in the lower and simpler forms. In the cranial types it is obvious that the human skull is more spherical and the face more nearly vertical than is the case with any other animal. The skull of the ape is more elongated and prognathic, and the facial plane is at a greater angle from the vertical.

In the scheme of nature there appears to be a fixed law of cranial projection, which coincides with other laws of anatomy and intelligence as indicated in the several scales above described. The cranio-facial angle in man, ABC (Fig. 2), is a right angle, and the gnathic angle ADE is approximately the same. The line FG represents the axis of the facial plane, and

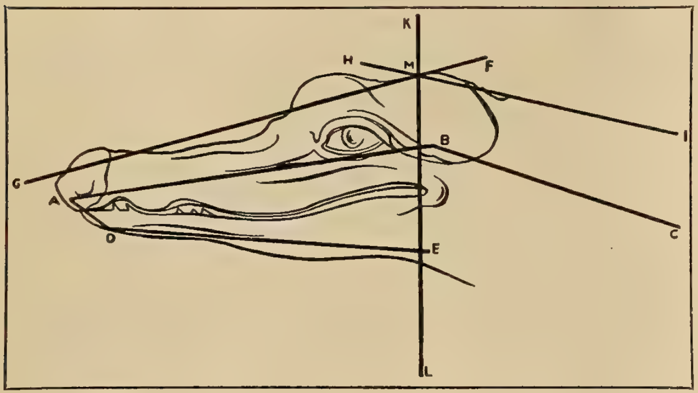


FIG. 5. CRANIAL PROJECTION OF A REPTILE

the line HI is the cervical axis. Reckoned from the vertical line KL it will be seen that the angles formed by the facial axis FG and the cervical axis HI are about the same on opposite sides of the vertical line KL. It will be observed that these lines and angles are those of man whose posture is upright. In Fig. 3, which represents the chimpanzee, it will be seen that both the facial axis FG and the cervical axis HI form greater angles from the vertical line than in man. It will also be seen that the cranio-facial angle ABC is increased by about one-half the angle of the facial axis GML. The gnathic angle ADE is increased in about the same degree.

Fig. 4 illustrates the lines and angles of monkeys in which the angles are widened in a degree measured by the tendency of the animal to assume a horizontal posture like that of true quadrupeds. In Fig. 5 is reproduced a model of reptilian forms of life to which the cranial projection of practically all the remaining orders conforms in principle. The facial axis FG and the cervical axis HI are almost horizontal. The cranio-facial and gnathic angles have been correspondingly widened, and upon a comparison of genera it will be found that this angle widens in proportion to the place of each particular genus in the scale as indicated.

Concurrent with these variations, the longitudinal, transverse and vertical axes of the brain also change their proportion in like degree in accordance with the animalian life and mind as outlined in the chart, Fig. 6. From the lowest animal forms which possess brains of the most rudimentary sort, some of them little more than ganglionic centers, we find infinite gradations of type as we ascend the scale of animal forms, and all in exact coordination of parts. The lower brains are long and narrow in shape. Reptilian brains are approximately four times as long as they are wide or high. That is to say their axes measure about 4 to 1; the *pachyderms* measure about 3 to 1; the *ungulates* about 3 to 1; the *carnivors* about 2½ (or 3) to 1; the *lemurs* about 2½ to 1; monkeys about 2 to 1; apes about 1½ to 1; and human beings about 1 to 1. Thus ascending the scale we find that the higher the stage of development the shorter becomes the longitudinal axis of the brain in proportion to the vertical and the transverse axes. The hemispherical type of brain becomes more and more pronounced, the details better defined, terminating in the marvelous complex brain of man himself. In other words, the cephalic model undergoes a steady metamorphosis, growing shorter and higher as its length diminishes with higher development. The measurements of the human brain average about 1,400 cubic centimeters; that of archaic man, about 1,000 cubic centimeters; and that of the ape brain about 600 cubic centimeters.

It appears that in one or two respects nature exacts a penalty for progress. With the development of reason, the instincts appear to fade. Man has lost his instincts to such an extent that they are no longer reliable guides to action. The apes have likewise forfeited a large portion of this animal inheritance, about in proportion to the substitution of the reasoning faculties. But the lower forms have the main, if not all, activities of existence guided by instinct alone. The very lowest forms of animal life possess certain qualities which seem to disappear as we ascend the scale. In those orders of life where fission is the manner of reproduction the organism has the power within itself of self-restoration, of reproducing members or parts of its body that have been destroyed. Pseudopods restore themselves; when a limb is severed another grows in its place. But as the forms of life become more and more intricate in structure, the organs become more and more specialized, and their power of recuperation becomes more restricted, until in mammalian forms, and especially those of the higher levels of life, the individual cannot even restore or grow a digit that has been severed.

Investigation along the above and similar lines might be followed *ad infinitum*, correlating the various aspects of comparative anatomy and their arrangement in a fashion concurrent with the evolutionary scale, which in turn coincides with the scale of comparative intelligence in animal forms presented herewith; but it is obviously impossible in the space here allotted to present all the data available.

The cordination is apparent and it is possible to employ it in a material way in research. *Given the gnathic angle, or the ratio of the cerebral axes, or the angle of the glottic plane with the larynx, or the number of digit movements, or the vocal range, or the number and qualities of items in the dietary of an animal form, and from any one of these indices it is possible to determine the others with fair accuracy and thereby assign any animal to its place in the scale of nature, physically and mentally.*

The foregoing glances over the various fields of anatomy, physiology and psychics are but general views of their broad panoramas, but they are sufficient to show the principles which govern the development of nature's types. They serve to demonstrate further the psychic unity of all animal life, and to vanquish man's foolish arrogance in according himself exclusive rights to all mental processes above those that are automatic or instinctive. The facts afford ample scientific grounds for believing that the hiatus existing between modern man and the lower extinct types of humanity has been entirely filled during the progress of the race from that low stage to the present one. Likewise, in view of the multitude of data in support of the Darwinian theory, and supplemented by the above coordinations, the same conclusions hold good of the hiatus between archaic man and the anthropoid apes and of that between the latter and the majority of lower animals. The scale shown here is not put forward as an exact measure; nor does it prove capable of containing

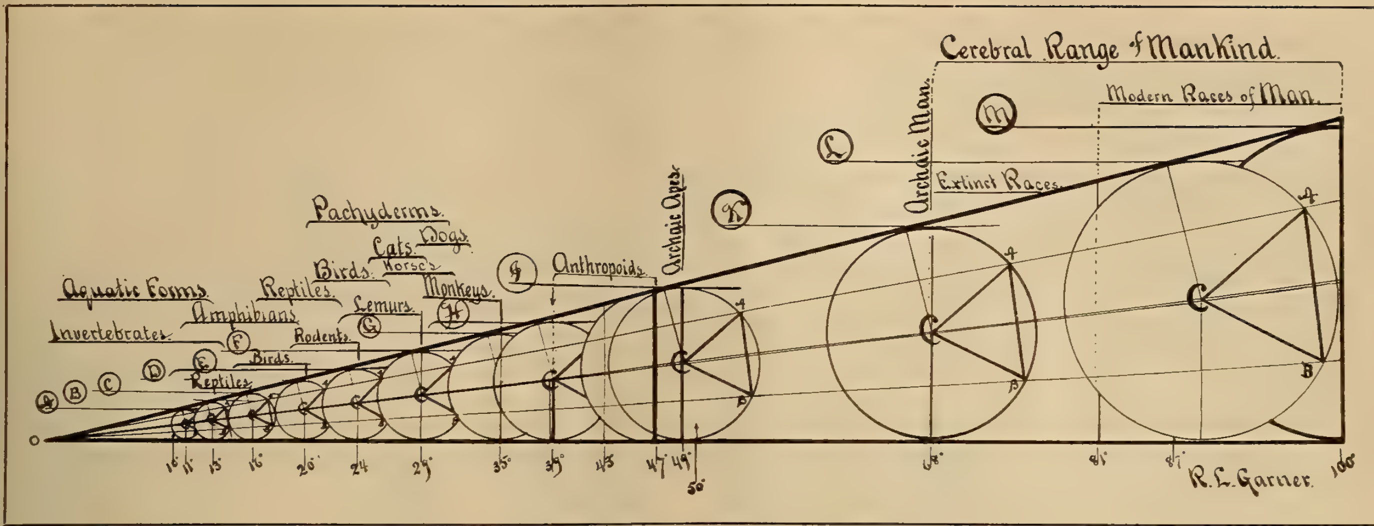


FIG. 6. CHART OF ANIMAL INTELLIGENCE IN WHICH LETTERS *A* TO *M* ARE TANGENTS OR HORIZONS OF THE SPHERES OF MIND AND CONCOMITANT FACULTIES

all forms of life in their endless variation. It is merely an indication of the principles at work in the development of vitalized matter through the ages, manifested in the comparison of animal types. Not all specimens or species conform to this relationship because of variations due to causes distinct in themselves predominating. But from the whole scale of comparative animal life the deduction is clear that every order, family, genus and species of animal lives within a sphere of life, or cosmos, all its own. And these correctly arranged fit into a perspective the outlines of which are tangents to the circumference of every one of these spheres of lief, from zero to its foreplane, occupied by the grand cosmos of man himself as the monarch of animalia.

Nature has its freaks which do not coincide with the general scheme, just as there are discrepancies in the mighty mechanism of the solar system. Science discovers anomalies in every field of research, but it does not abandon a principle because of them. The imbricating circles of animal life, the unity of plan and purpose, the inherent relationship of types, the foetal history of forms, the possession in common of the gifts of nature, stand out as cogent facts with stereopticon clearness in proof of the unity and continuity of design in the realm of vitalized matter. Mind is essentially one in kind, from the acme of human attainment to the protozoa; and it is as universal as the vital phenomena which we call life.

THE USE OF AUTO-SERUMS IN THE ART OF HEALING

One of the newest methods of treating certain infectious maladies is by means of a serum taken from the body of the patient himself. Two different processes are employed in this method, which is technically known as auto-serotherapy.

The first method was devised by Dr. Gilbert of Geneva for employment in cases of sero-fibronous-pleurisy of slow development. The operation consists in extracting by means of a puncture a small quantity, only a few cubic centimeters, of the liquid discharged, and then injecting this beneath the skin of the patient. In about half of the cases thus treated the development of the disease was suddenly accelerated and recovery was comparatively prompt. It must be noticed, however, that this effect is not produced, or but rarely, when the injection is made during the period while the pleurisy is augmenting. The explanation of this remains rather obscure. P. Courmont is of the opinion that when the pleural liquid has been maintained at its maximum level for several days the anti-toxins balance the toxins and that the absorption of the discharge is not definitely begun until the anti-toxins are in the ascendency, so that as a result the *vaccination* is complete. But since this vaccination is sometimes very slow in establishing itself it may be of advantage to hasten it either mechanically by a simple explorative puncture or else by auto-serotherapy. Other authorities suppose that the injection simply releases a diaphylactic reaction which modifies the colloidal state of the liquid so as to facilitate its absorption.

In the second process it is the serum of the blood of the patient which is employed instead of the discharged liquid. Widal, Abrami and Brissaud have shown that it is possible to obtain by this means very valuable results in case of certain infections; it was thereupon employed in serious broncho-pulmonary affections and in cases of grippe. The patient is bled and the serum is allowed to settle in a sterile place and the serum was then reinjected under the skin or into the veins. The intravenous injection is frequently followed by violent reactions on the patient's part (shivering, advance of temperature, curious thoughts of ill-feeling, etc.), and sometimes, indeed, by anaphylactic accidents; but after this the temperature falls and there is a general improvement in the condition of the patient, which may be definitive. The effects just mentioned are those which are invariably observed when foreign bodies are introduced into the circulation, whether directly or indirectly, such as peptone, sugar, colloidal metals, horse serum, emotions of bacilli, etc. But the serum of the patient has itself become the cause of the necessary manipulation of the blood, a foreign body, and this fact forms the explanation of the reaction and the therapeutic results described above. However, this process involves so many difficulties of technique in order to avoid the contamination of the serum that it is but rarely employed, it being considered preferable either to make an immediate injection of the blood of the patient, as is done by Artaud de Vevey or else to inject the citrated blood or plasma of the convalescent according to the methods followed by Grigaut and Moutier.

A BIRD THAT BUILDS AN INCUBATOR

A remarkable example of a sort of artificial incubation is found, according to a writer in the *Naturw. Umschau v. Chem.-Ztg.* (Berlin) for November, 1920, in the brush turkey (*Talegallas*) which is a native of Australia and New Zealand. This bird prepares a sort of incubator for its eggs which relieves it of much of the labor of brooding over them, which other fowls find necessary. It scrapes together with its strong, muscular feet a great mass or mound of withered leaves and decaying vegetation in which the female lays her eggs, arranging them in a neat circle. The decomposing vegetation soon begins to produce the needful warmth for developing the eggs. Meanwhile the male bird visits this great compost heap from time to time to regulate the temperature, and when the time for hatching comes to assist the young birds in extricating themselves from the decaying mass in which the eggs are reposing. He does not permit his youngsters to leave their warm home, however, until they are fully fledged.

Mutation and Evolution*

Some Interesting Recent Experiments by Van der Wolk

By R. H. France

IT must be admitted that the doctrine of evolution no longer awakes the burning interest which it did some fifty or a hundred years ago. It now divides human interest with many other fields of knowledge—perhaps indeed with all of them. At a time when electricity was not a matter of common knowledge to every peasant boy through the electric light and the dynamo, but was familiar only in physical laboratories through a few chosen experiments which now-a-days appear to be not only simple but even childish in nature, many people found not only physical but spiritual thrills even for a life time in its phenomena, as one may read in the Memoirs of the Duke of Lauzun. Before the day when every neurologist became capable of exercising hypnosis, but when Mesmer alone professed to evoke "magnetic sleep," all Europe hung breathless upon this strange affair as upon the founding of a new religion.

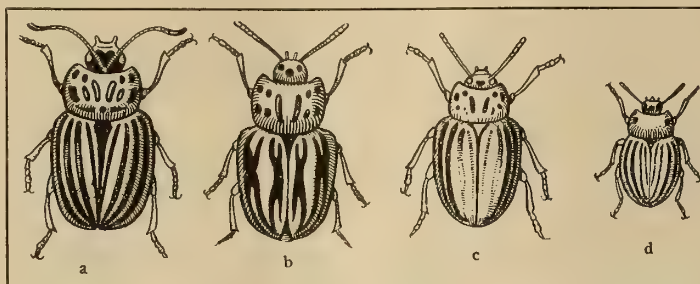


FIG. 1. MUTATION OF THE COLORADO POTATO BUG (*LEPTINOTARSA DECEMLINIATA*)

The type shown at *a*; *b*, *c*, *d* show varieties produced experimentally, but which also make their appearance among local native species and become stable under certain conditions, through heredity. (After Tower.) About 2½ diameters.

Taken by and large mankind is both ungrateful and short sighted. It turns with burning zeal to those matters which it does not understand and loses interest in them as soon as they are explicable and useful. Being in a certain measure disenchanted they remark languidly, "Oh, that's easy to explain like this," etc.

The same thing has happened to the theory of evolution; when Haeckel and Huxley, following in the hesitant steps of Darwin, laid down its laws in bold clear lines, it was an event of European importance. And yet at that time their opinions concerning it were of as hypothetical a character as ours today concerning the canals of Mars. More than fifty years have passed since that time and today everything definitely known and worthy of belief in regard to the theory of evolution has again become a mere "technical matter"; the "fight over Darwin" is stilled, at any rate, so far as the public is concerned. In its place there has come to the fore during the last decade or so a "fight about the mutation theory" which, at least, with respect to the great material value which it involves deserves the attention of the general public.

*Translated for the Scientific American Monthly from *Kosmos*, (Stuttgart) for July, 1920.

The concept of mutation, which first made its appearance in 1903 in a work published by the Dutch botanist, Hugo D. Vries, has after some hesitation been pretty generally accepted as furnishing an explanation for the sudden appearance of new and inheritable characteristics in the animal and the plant. The significance of this view resides primarily in the inheritability of such characteristics and neither in the fact that they are peculiarly striking nor in the fact that they are absolutely new. For example, the moss rose constitutes a mutation which once appeared in a garden and which can be perpetuated both by grafting and by seeds. The merino sheep presents another case of mutation. In 1838 an English ewe gave birth to a lamb having long silky hair, which character was inherited by its progeny. In the same manner the much admired cactus dahlia suddenly made its appearance in Germany, in a plant grown from American seeds.

The divergent races of a certain Colorado potato bug (*Leptinotarsa decemlineata*) also represent mutation; these were first obtained experimentally by Tower and then were discovered in nature; their characters which are pictured in Fig. 1, are inheritable.

Mutations have been found in every group of the plant and animal kingdoms from the bacteria to the domestic animal, and this vast material enables us to gain a certain insight into the laws which govern their appearance. Such mutations occur with especial frequency in years which are unusual with respect to climatic conditions; a second exciting cause is recognized in the transplantation of an organism into a new environment, the most famous example of which is the classic example of all mutations, that of the evening primrose (*Oenothera*) which was discovered by De Vries growing wild in a locality near Amsterdam. A third group consists of cases found among plants and animals subjected to domestication, and a fourth among those unhappy guinea pigs used for experiments, who often exhibit sudden alterations.

From this alone it is possible to deduce a certain conclusion; to employ the terms which best express our modern perception of the nature of life these mutations make

FIG. 2. AN ORDINARY MAPLE LEAF AND *ON THE RIGHT* ALTERED FORM OF WHITE MAPLE LEAF

FIG. 3. GREEN TWIG WHOSE TIP HAS BEEN ARTIFICIALLY INFECTED

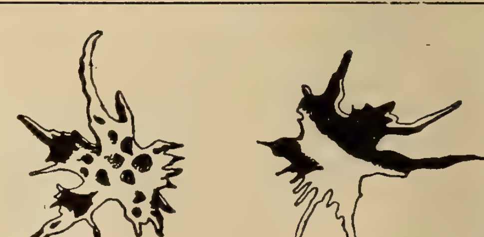


FIG. 4. HYBRID PRODUCED BY CROSSING ORDINARY MAPLE LEAF WITH DISINFECTED WHITE MAPLE

their appearance as "responsive reactions." In other words they represent the responses given by the plant to certain definite and extraordinary alterations in environment differing from the usual adaptation to environment only in the fact that they have become definitely fixed and are, therefore, transmitted from parents to offspring. The Vienna biologist, Paul Kammerer, a very successful investigator in this field, expresses this fact in the following neat sentence: *"Mutations are acquired hereditary characters."*

De Vries makes the statement that mutations are due to internal causes which he expresses in the following manner: "Shocks to the molecular structure of the germ plasm"—this, however, is a mere description and, moreover, a description of a purely hypothetical occurrence. Just here lay the weak point of the entire doctrine of mutation. The mutation appeared to be merely a violent mingling of character already present in the plant and the supporters of this theory had no conclusive answer to the objection that all mutations might possibly be merely the hybrids of parents and progenitors unknown to us.

At this juncture of the question Mr. P. C. Van der Wolk published (in *Cultura*, 1919), some noteworthy observations on the study based upon the investigations of nine years.

An ordinary maple shown in Fig. 2 was pruned in the autumn, whereupon in many places the marks of the pruning shears exhibited the appearance of rot. In the neighborhood of these points the tree sent out shoots bearing leaves not only different in form but in color, the latter being white while the former suggested the *Lanciniatus* form of the gardeners. These sprouts bore blossoms and these flowers differed from the ordinary bi-sexual flowers of the maple by being mono-sexual. Here then we have a case of a classic variation by saltation or "jumping" without any transition process; furthermore, this modification contrary to the usual rule proved to be permanent. In short we have here a case of a new kind of maple produced by a sudden mutation. It occurred to Van der Wolk that this apparition of a new form might be connected with the rottenness affecting the wounds received from the pruning shears. He therefore made a bacteriological examination of these injuries and succeeded in isolating a certain bacillus therein. When normal green boughs were inoculated with this micro-organism they put forth white leaves. Thus we have an instance of an artificial production of an alteration of color, as shown in Fig. 3. When normal seeds were planted in ground which had been inoculated with these same organisms they produced plants of altered character. Here then we have at hand a simple means of producing mutation by means of bacterial inoculation and this obviously constitutes a vital stage of progress in the doctrine. Moreover, the supporters of this view will rejoice at a further proof that the vital phenomena of plants may be regarded as a logical series of reactions.

Van der Wolk recalled an observation to the effect that plants which are attacked by fungi produce an increased amount of calcium oxalate, succeeding thereby in killing the parasite. He proceeded to inoculate young maple boughs with calcium oxalate without obtaining any result in the first instance except that the cell sap of the branches thus treated was no longer susceptible of forming bacterial cultures. The inoculation appeared to kill the bacteria. But it was a remarkable fact that when the progeny of white-leaved plants which had been thus disinfected was crossed with normal green-leaved plants the result was the appearance of *spotted hybrids* (Fig. 4) whereas when the white and green plants were crossed without the previous disinfection of the former the offspring always consisted of *white plants only*.

In Van der Wolk's opinion these results indicate with absolute certainty that the doctrine of mutation is no longer in danger of being overthrown by the theory of hybridization. If these experiments are repeated, varied, tested, and confirmed, still more important conclusions may be drawn from them.

Mutations may finally be regarded therefore as the response made by the organism to a disturbance of the harmonious development of the life process, and thus fall into the vast domain of *adaptations*, especially of heritable adaptations.

It would thus appear that one of the most violently debated questions in the doctrine of evolution, *i.e., the inheritance of acquired characteristics*, upon which is based the entire recent view concerning the phenomena of life, is here decided experimentally. And this is a far weightier matter than the phenomenon of mutation itself, interesting as the latter undoubtedly is.

For if it be true that acquired characteristics can be inherited, then every thing that the organism is now or may become is the heritage of experience and the work of its progenitors, and this furnishes us with a key wherewith we may unlock the thousandfold chambers of the evolution of the organic world.

And this first fruitful piece of work along the path of an *experimental doctrine of evolution* justifies us in hoping for the final success of the belief that *adaptation is the product of work done and of that eternal logical connection between cause and effect which rules the universe.*

For the first time man is able not merely to form a theoretic concept of the creation of life, but beholds the law governing that creation. And he would not be the self-seeking creature he is and must be to support his position between the upper and nether millstones of existence did he not at once begin to dream that through his knowledge he may become the lord of this law.

PHYSIOLOGY OF THE APPLE

THE trees used in the study were from a 7-year-old orchard on sandy soil near Exeter, N. H., of the Golden Ball variety. Two trees were taken for analysis, the analyses being separately made in each case. Samples for analysis were collected (1) during dormancy; (2) at the awakening of vegetation; (3) when in bloom; (4) as soon as active growth ceased, and (5) at leaf fall. During the dormant period the roots contain more starch than the trunk and limbs, the limbs contain least, but during the budding season the branches contain most. During the 4th period the trunk contains relatively more starch than the roots or branches, and at the 5th the roots again contain more. Sucrose is present in all parts of the tree at all times. During dormancy it is most abundant in the small roots; then follow in decreasing order, 1-year-old branches, then 3-, 4-, 2- and 5-year-old branches. At the budding period the 1-year-old branches are relatively much richer, while the roots have lost heavily, the older branches are slightly poorer. At blossoming time and at the close of growth the roots are richer. The changes in sucrose content of the different parts of the tree are very largely independent of the starch. It is concluded that sucrose is primarily a reserve food material and not simply an intermediate stage in starch hydrolysis. At the beginning of vegetation reducing sugar is formed, at the expense of sucrose, the hydrolysis being more marked in the small roots. The reducing sugars accumulated in the small roots are translocated to the growing parts prior to blossoming, when they are utilized in tissue formation. Reducing sugar appears to be the main migration form of the carbohydrates. Fats are always present in the apple and apparently function as reserve food material since they disappear from the roots during the early stages of growth and accumulate in the 1- and 2-year-old branches. The nitrogen reserve materials are stored mainly in the younger branches from which they pass to the actively growing regions upon the awakening of vegetation. The phosphorus required in building new tissues at the awakening of vegetation is mainly obtained from the younger branches, while the translocation of potassium occurs mainly from older parts than those that supply the needed phosphorus and nitrogen.—Abstracted through *Chemical Abstracts* from *Tech. Bull.* 13 (1920). of New Hampshire Agr. Expt. Sta.

THE MOUTH OF THE FRITTON DECOY FOR TRAPPING WATER FOWL

The Fritton Decoy

A Curious Method of Snaring Game

THE section of England known as Norfolk Broads is a highly interesting one and is a great vacation center in summer. A triangle, having the coast for its base, Lowestoft at the left, and Palling at the right angle, with Norwich at its apex, will contain nearly the whole of the Broad district with its 5,000 acres of lakes and broads, and 250 miles of navigable rivers. In these, say, 250 square miles may be found during a holiday trip delightful occupation for seekers of "fresh scenes and pastures new." For the angler such sport awaits him as he cannot obtain elsewhere as the takes of fish at certain times and places are simply extraordinary, especially of the coarser kinds of fish, such as bream, pike, etc. He may choose for his fishing ground water either deep or fleet, running or still, clear or obscured, with the assurance that he will not go away either empty-handed or disappointed.

An interesting excursion may be made from Lowestoft to what is known as Fritton Lake or Fritton Decoy, where the snaring of wild fowl is carried on by a contrivance peculiar to these and other nearby waters, so that an explanation of these decoys may prove of interest.

Mr. G. Christopher Davies, an authority on the Norfolk Broads and Rivers, writes of Fritton Decoy as follows:

When with the approach of winter the wild fowl come to us from northern latitudes they find but little of that quiet and seclusion which are necessary to their abiding with us in any great numbers. The protuberance of Norfolk and Suffolk into the North Sea arrests a large number of the southward-speeding birds, and the great lagoons, silent rivers, and far-stretching marshes of East Anglia offer them a safer harborage than do other parts of England. Yet the proportion of fowl remaining even in so suitable a district is not by any means so large as formerly. Of course there are many reasons for this: marshes are drained and lakes lose their wildness, the number of sportsmen is greatly increased, and no spot is long free in the winter time from the noise of guns. The chief cause, however, in our opinion, is the decadence and disuse of decoys; and this view is shared by most of the 'water-abiders' among the Broads.

One night, while out on a certain quest on the river Bure, near Ranworth, in the midst of the best possible grounds, or waters rather, for wild fowl, we were struck by the scarcity of ducks going to and fro at night and morning 'flight' time: and on remarking this to the eel-fisher who was with us, he said, "Oh, it was a bad job the giving up of Ranworth decoy. When that was worked there was plenty of fowl for the decoy and plenty for the flight-shooters, but since the decoy was given up and the Broad shot over, the ducks don't come and nobody gets any."

The reason of this is obvious when the habits of ducks are considered. They feed chiefly by night, when, in the cover and silence of the darkness, they fly to different feeding grounds which they dare not visit in the daytime. Just before dawn they fly back in small bodies to some sequestered lake where the argus eyes of numbers collected together afford a feeling of security to the timid fowl. If they are not disturbed in their retreat they spend the daylight there, feeding a little, sleeping a little, and preening themselves until the night gives them leave to go forth in fancied safety. It is while they are thus collected in numbers that they fall victims to the decoy. So silently and skilfully, however, is the decoying practised that while half a hundred ducks are having their necks wrung by the decoy man within fifty yards of the water's edge, hundreds more may be sitting on the water close by all unconscious of the tragedy which is being enacted.

No phase of the pursuit of wild creatures by man for food or profit is more interesting than the system of decoying wild fowl, as practised for generations in East Anglia. Wild-fowl decoys have decreased sadly in number during the last generation; yet in these days of depressed agriculture, it is surprising that gentlemen who have the opportunities of suitable possessions do not embark in what is really a profitable pursuit. A small wild-fowl decoy would pay better than a small farm nowadays, and at a smaller expenditure of capital and labor.

A CURVE IN THE DECOY SHOWING THE OBLIQUE SCREENS

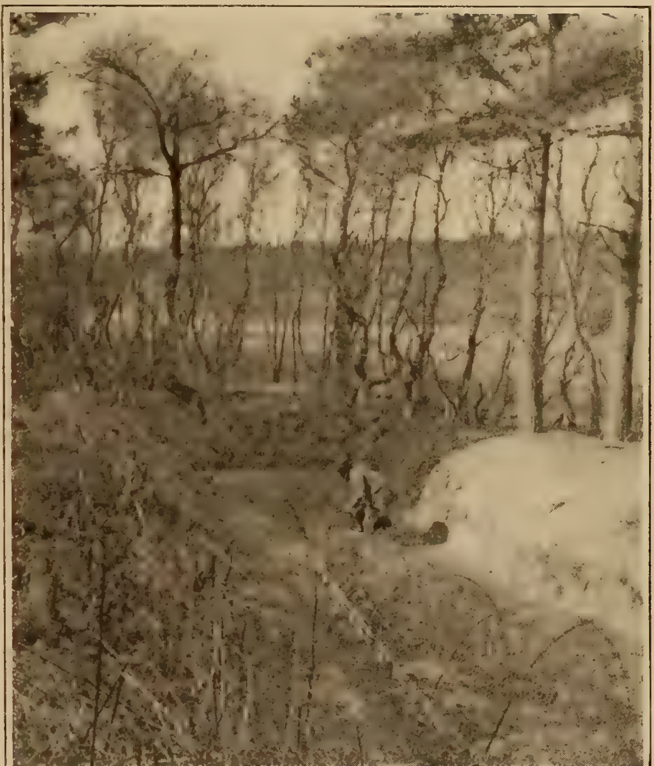
Much of the mystery which formerly surrounded the working of decoys has been dispelled by the patient investigations of Mr. Thomas Southwell, F.Z.S., who has gone into the subject with loving zeal and made his discoveries public. It is to him that the writer owes the pleasure of seeing a decoy worked.

Fritton Lake is not, strictly speaking, a "Broad," as it is not connected with or a broadening of any river. It is also out of the marsh district, in a sylvan part about three miles from the coast, and midway between Yarmouth and Lowestoft, and is really a deep lake, about three miles long and a sixth of a mile wide, of a straggling and irregular shape, lying between wooded banks of great beauty, and with numerous creeks or indentations of which advantage has been taken to construct the decoys. There are two groups of decoys, one at each end of the lake, and those we saw worked are at the east end, and are the property of Sir Saville Crossley. A decoy should be sheltered from all observation of passers-by on roads or fields; but owing to gaps caused by the falling of large numbers of trees in a great gale we could catch glimpses from the highroad of the water in the secluded bay where the decoys lay. Two or three score of ducks were swimming quietly about, and the keeper told us that men driving by would, out of sheer wantonness, crack their whips or shout for the purpose of putting the fowl to flight. He had built up huge bastions of reeds in the spaces left by the recumbent trees to screen the decoy; but the damage caused by the gale was not so easily set right, and the fowl were much shyer than before. Decoys are worked, if fowl are plentiful, twice a day—morning and evening. The weather in which the most ducks came was snowy, cold weather, when the ground was covered with snow, and food hard to get at, yet when the frost was not severe enough to "lay" the larger pools. At the time of our visit the decoy had not been worked for a few days, and some fowl were present, but very shy, as some one had been passing up wind of them, and the keeper had seen a footmark in the wood which was not his own. Cautioning us to stoop as low as he did, not to cough or sneeze, or speak above a whisper, or tread on a dry branch, the keeper gave us a bit of smouldering turf, the object of which is to destroy the human scent, which would otherwise travel down wind and alarm the ducks.

Like all other birds, ducks like to swim or rise with the wind in their faces; hence it is only possible to work those pipes which are to windward of the birds, and in all decoys there are pipes made to suit the prevailing winds.

The decoy-dog accompanied us, and was a retriever of reddish color, red being apparently a color which more powerfully excites the curiosity of the ducks than any other. This dog was a large one—too large, the man said, inasmuch as small dogs were found to be more effective. As we approached the lake we entered a dry ditch, with a bank thrown up on the side next the water. This was the "traverse," or means of approach to the decoy; and along a series of these traverses we proceeded crouching double, hats off, the peat-smoke making our eyes water, and the dog tripping us up. There was something decidedly conspirator-like in this stealthy progress over the soft dead leaves in the narrow ditch, and under the deep gloom of the trees and bushes which shaded the earthworks; and our expectations were wound up to a high pitch, our eagerness being, however, checked by our guide, who, in hoarse whispers, bade us "keep lower, keep lower."

In order that the reader may understand the subsequent proceedings we will leave ourselves crouching breathlessly behind the reed screens while we explain what an after-inspection, when there were no ducks present, revealed of the plan of a decoy. Out of the quiet wood-surrounded bay, dykes, or arms of water, extend into the land. Each dyke is about 18 feet wide at the mouth, and gradually narrows to a point, curving the while to the right, or with the sun for about the quarter of a circle, and is 80 or 90 yards along the curve. Over this dyke are light arches, sometimes made of long pliant rods and sometimes of iron. These, again, are covered partly with cord network and partly with galvanized wire netting, the network being generally near the mouth, where it is more invisible than the wire, and the wire netting over the rest. These avenues of netting are called "pipes," and are, speaking roughly, 10 feet at the open end, diminishing rapidly to 3 feet in diameter. At the small end is a pair of double posts in the groove between which slips the first hoop of the "tunnel net," which is a bow-net 8 or 10 feet long, the extreme end of which is stretched out and tied to a stake. Owing to the curve of the pipe, the ducks in the decoy can only see a short way up it, and the massacre of their comrades and the move-



THE END OF DECOY PIPE WHERE FOWL ARE CAUGHT

ments of the decoy-man are unseen by them. Along the outer curve of the pipe, for a distance of nearly half its length from the mouth, screens made of reeds are placed obliquely, overlapping each other, and about a yard apart, the openings looking up the pipe; while toward the lake they present an impenetrable front. Continuous screens along the edge of the lake near the pipe and outside the pipe and oblique screens still further add to the secrecy.

Inside the pipe is a wire-work pen, in which is immured a lively quacking duck. The water in front of the pipe and inside is kept free from weeds, and is very shallow, with, if possible, a hard bottom, so that the "feed" with which the decoy is plentifully supplied may be easily seen and got at by the fowl. The oblique screens are connected by low barriers called dog jumps. Through two or three of the screens flat sticks of wood are inserted edgewise. If these are turned flatwise, they form small openings or peep-holes, through one of which the keeper has been peering while we wait.

Blowing his turf to fan the smoldering fire, he beckoned us on, but with emphatic gesticulations to keep low. He planted each of us at an eye-hole, and then we saw a very beautiful and interesting sight. Quite at the mouth of the pipe was a flock of teal paddling quietly about, some with their heads tucked back, fast asleep, and others toppling over, feeding on the grains which had sunk to the bottom; but the greater number just floating lazily, with the sun shining on their glossy blue and chestnut heads. It was indeed a curious sight to see these wild and timid little creatures within a few yards of us, all unconscious of the presence of three men intent on their capture. We held our breaths for fear of disturbing the intense stillness which reigned around—a stillness so great that the cry of a distant jay caused the ducks to lift their heads in listening attention. Beyond the flock of teal were several decoy ducks—tame ducks of a color and marking as nearly as possible like the mallard. These decoy ducks are kept in the decoy, and trained to come in for food whenever they see the decoy dog, or hear a low whistle from the decoy-man. Beyond the decoy ducks was a flock of mallards, looking large and sitting high on the water compared with the teal.

Then the obedient decoy dog jumped over one of the jumps on to the narrow strip of margin within the pipe, and so became visible to the fowl, returning to his master over the next one. In an instant every head was up among the teal, and with outstretched necks they swam toward the dog, their bright eyes twinkling, and every movement indicating a pleased curiosity. They halted as the dog disappeared; but as, at a sign from the keeper, he jumped into the pipe again higher up, the birds again eagerly followed him. They were now well within the pipe and directly under my nose. The keeper ran silently toward the mouth of the pipe so as to get behind them, and then appearing at one of the openings between the screens, he waved his handkerchief—a motion invisible to the ducks still outside the pipe, but a terrifying sight to those within. In an instant they rose and flew up the pipe in a panic, the man following them up and waving his handkerchief at each opening. As the pipe grew narrower, the doomed birds struggled along, half flying, half running. Only one dared to turn back and fly out of the pipe, regaining safety by its boldness. The others crowded through into the tunnel net, and when all were in, the keeper detached the first hoop from the grooves, gave it a twist and so secured the ducks.

Except to work the decoy, the keeper never approached it in the daytime, all necessary work being done after the "rising of the decoy," that is, after the fowl had left on their nightly excursions. In hard weather, when the ice formed during the night, it had to be broken in the early morning before the ducks returned, as, unless the pipes and a space of water in front of them were kept open, the decoy could not be worked.

We learn that about six decoys are now worked either regularly or occasionally in Norfolk. The present rage for shooting will go far toward exterminating the decoys, and landlords who feel the pinch of tenantless farms, will let the shooting of places which for generations have not been disturbed by the sportsman's gun. We find that at the decoy now being described the average take of fowl each season is 1,000. This last winter, however, it was very small, as, on a visit there in the spring, the keeper said that only about 250 fowl had been taken—less than a day's work in more prosperous times.

In a shed at the keeper's cottage the fowl were laid out and counted—21 to our computation, 11½ to the keeper's; the reason being that teal and widgeon are only accounted as "half-fowl," and two go to one mallard, or twenty-four to the dozen.

Our next visit to Fritton was in the following spring for the purpose of photographing the salient points of the decoys, and we were favored with a still, bright day. We first visited the decoys at the Fritton end of the lake, and the views of the screens and the interior of the pipes are of these decoys. The view, representing the end of the pipe and the tunnel net, is the one which we had seen worked in the winter. Altogether we obtained sixteen negatives, all of them good and typical, and a set as unique as in a few years' time they will be valuable. The lake was then merry with Easter Monday holiday parties, and picnics were held at the very mouth of the pipes. The decoy ducks were still swimming about the decoy, and we found some of their nests among the rough herbage and brushwood behind the pipes. A curious fact in connection with these nests was, that the birds on leaving them covered the eggs over with dead leaves so as to hide them. This is an interesting bit of evidence in favor of reason rather than instinct, for these were domestic ducks leading a semi-wild life and taking the precautions observed by wild-fowl.

DIFFERENCE BETWEEN MOLDS AND WOOD DESTROYERS

NOT all fungi which live upon wood impair its strength, but conditions which promote the growth of molds, blue-stain fungus, and other non-injurious fungi are usually favorable to the growth of the wood destroyers, and these may be active on the same wood bearing the molds. Hence, the presence of mold on timbers intended for any structural purpose should cause them to be looked on with suspicion.

In the early stages of their growth the molds and the wood-destroying fungi sometimes have a very similar appearance, and there is no simple means known to the U. S. Forest Product Laboratory by which lumbermen and wood users can separate them at sight. The surface growth of molds is generally cottony or felty in appearance; the mycelium or fine mold threads are interwoven, never compacted into membranous sheets or strands. The mycelium of wood destroyers may be fluffy and glistening, but more usually are compacted into strands or fan-shaped patches.

The characteristic feature of mold growth on wood is the fact that the minute threads which enter the wood do not bore into the wood fibers or dissolve them away. They pass through the spaces between the fibers or enter them through the natural openings, called pits, which are found in the walls of certain cells. Starches, sugars, and other contents of wood cells constitute the food of the molds.

The wood-destroying fungi are able to send their threads right through the wood fibers, breaking down the cell walls and utilizing portions of this decomposed material as food. This action very markedly weakens the wood, making it crumbly, stringy, or spongy—in other words, producing rot or decay. The presence of wood-destroying fungi in an advanced stage of growth is evidenced by fruiting bodies, commonly called mushrooms, toadstools, conchs, or brackets.

The principal economic loss caused by molds is through the staining or discoloration of the wood. No greater injury may be caused by the wood destroyers in their early stages; but their work will continue and finally result in the destruction of the wood if favorable moisture and temperature conditions prevail.

The Alternation of Generations

A General Law Governing the Development of Both Plants and Animals

EVERYONE is familiar with certain instances of the phenomenon known as the alternation of generations in living creatures. Few people are aware, however, that this is a general law governing the development of both plants and animals. It was first clearly recognized by Hofmeister in the mosses and the ferns.

As we all know ferns bear no flowers, but the lower surface of their leaves is covered with a fine powder consisting of spores which are borne away by the slightest breath of air. When these spores fall upon suitable earth and at the same time find favorable conditions of heat and humidity, they germinate. But strange to say the resulting plant is not a fern! From the spore there first sprouts a short green filament, whose end expands and spreads out upon the ground so as to form a green cordiform blade having a diameter of barely a centimeter. This is the "thallus" (sometimes called prothallus). These thalla are produced abundantly in the dry earth in which exotic ferns are cultivated, both the surface of the earth and the walls of the flower pot being thickly sown with them. The thallus lives a perfectly independent life, obtaining the mineral salts which it requires from the earth by means of the hairs which serve as absorbents as well as fixators of the plant, and at the same time building the carbohydrates of which it has need from the carbon-dioxide in the air by means of the chlorophyll in its own cells.

The thallus is, as a matter of fact, a plant with a definite individuality; it is capable of reproducing itself by means of cuttings; it is generally very ephemeral in character and, finally, it forms no spores; hence we see that it is an organism which is very different in nature from the fern which gave it birth.

In the adult state the thallus forms sexual organs which produce sexual cells or "gametes." As in most plants and animals the female gametes are comparatively large and each one is contained in a sort of bottle with a neck. The male gametes are much more numerous and are very mobile. In due time the latter perform their proper functions of fecundating the former.

Starting with this typical example Mr. L. Maltruchot, a French savant, contributes a most valuable article on the subject to the April (1920) number of the well-known scientific magazine *Scientia* (Milan).

Speaking of this particular case, the author remarks:

"The fecundation here consists in a fusion of the two kinds of cells, protoplasm with protoplasm and nucleus with nucleus, in such sort that the product of the fecundation is a single cell, the 'egg,' which becomes the point of departure of a new development. Lodged in the mass of the thallus from which it derives its nourishment the egg increases in size, undergoes the process of division and in this manner develops so as rapidly to form an embryo, in which it is soon possible to discern a little root, a first leaf, and a bud. It is, in fact, a miniature fern which will gradually increase in size until it has become a large and leafy fern capable of producing spores.

"When first formed the young fern is fed from the thallus but later it abandons its parasitic life and acquires an independent life thanks to its root and the chlorophyll of its first leaves. Meanwhile the mother thallus, exhausted by the growth of the little fern, withers and dies."

Obviously here we have a complete cycle consisting of two phases, the *thallus* which produces gametes, constitutes the gametophyte phase, and the leaf-bearing fern which produces spores and is, therefore, called its sporophyte phase. Between these two phases there is a remarkable antithesis, not only in form, structure, and size, but likewise in origin and in end.

THE MOSSES

"The same scheme of development is found in the mosses. But here it is the comparatively large plants commonly known as moss, *i.e.*, a greatly developed thallus, comprising an erect axis provided with expansions in the form of leaves and attached to the ground by absorbent hairs with which we are concerned. This 'leafy thallus' is a true gametal type, since it forms gametes of both sexes whose union results in eggs. Each egg attached to the mother plant develops into a sort of erect stem without branches which finally produce spores. This organ, which is called by botanists the 'sporogone' represents, therefore, the sporophyte phase of the moss; it lives indefinitely as a parasite upon the mother plant without ever freeing itself." Thus we see that while the cycle of development is the same in these two groups, in the ferns it is the sporophyte phase which is most important and most greatly differentiated, whereas in the mosses it is the gametophyte phase which is predominant.

Recent researches upon the physiology of cells have led modern botanists to the conclusion that the formation of the egg and the formation of the spore are in a certain sense antagonistic, constituting, as it were, the two poles of the plant's development. Mr. Maltruchot thus discusses these stages:

"The formation of the egg as a result of fecundation consists essentially of the fusion of two gamete-cells. But whatever may be their differences of size or of form these two gametes appear to bring to the union *practically equal quantities* of a substance contained in their nuclei which has been termed *chromatine* because of the affinity it exhibits for coloring matters. This chromatine is borne by the corpuscles in the form of rods known as *chromosomes*, and *two gametes of the same species always contain the same number of chromosomes*.

"As a consequence the nucleus of the egg formed by the union of the nuclei in the two gametes contains twice as many chromosomes as either of the gametes.

"Still another fact has been thoroughly established by cell study, namely, that when a cell divides into two 'daughter-cells, the amount of chromatine in the nucleus is divided equally between the two new nuclei and save for an exception, which we will refer to later, each of these two nucleus-daughters contains the same number of chromosomes as the nucleus of the mother cell, so that all the cells proceeding from the sectioning of the egg will have bivalent nuclei.

"But upon the formation of the spores a new phenomenon makes its appearance; the spores are born four by four from a mother-cell called the tetrad cell. This tetrad cell undergoes two rapid divisions in succession in the course of which the number of chromosomes appear to be reduced to half. If the mother cell possesses eight chromosomes each spore will possess only four.

"We see, therefore, that while at the formation of the egg the number of chromosomes is doubled when the spore is formed the number of chromosomes is reduced and the spore carries with it the 'reduced' number of chromosomes, or rather the 'simple' number of chromosomes.

"This simple number persists in all the divisions which succeed each other, beginning with the germination of the spore and, as a result of this all the cells of the gametophyte possess monovalent nuclei. The same thing is true of the gametes and thus we have come back to our point of departure."

The ingenious theory thus formulated by Hofmeister has been extended, thanks to modern cell study, not only to those plants known as gymnosperns but also to the phanerogams of

flower bearing plants. This governing idea has controlled the study of the embryogeny of the higner plants for more than fifty years, and it is a well established fact in the view of modern botanists that this law of the alternation of generations is operative among the higher plants in the sense that the scheme of development, given above applies to them as well as to the plants of lower organization, such as mosses and ferns.

"But in proportion as we go higher in the series of the flower-bearing plants," remarks our author, "we observe a sort of decadence of the gametophyte. In a lily, for example, or a butter cup, the gametophyte is represented merely by a mass of certain cells in the body of the ovule, or by one or two cells of the grain of pollen. So that we may consider that among the higher plants the entire body of the plant, including root and stem, leaves and flowers, represents the sporophyte phase, the spores to which it gives rise being the so-called 'microspores' which eventually become grains of pollen, and the so-called 'microspores' which remain included in the tissue of the interior of the ovule."

He even adds that the same general law of development holds good in the immense majority of animals, particularly in all those higher animals in which the gametophyte phase is likewise reduced to a few lines of cells which give birth to the sexual elements. Among these also we may consider, therefore, that there exists an alternation of generations, no longer, to be sure, in such a special sense as it exists among the Hydras and Medussas, "but in the general sense which we have defined as a result of our cell study."

He sums the matter up by declaring it as his fixed opinion that the alternation of generations forms a biological law of the most widespread application, governing the development of all the more highly organized living creatures, whether plants or animals.

In the May issue of *Scientia* the author continued the study of alternation in generations as applied particularly to the life cycle in the lower order of plants. The following is a direct quotation of this second article:

STUDIES OF THE LIFE CYCLE IN THE LOWER ORDERS OF PLANTS

"In the first portion of this study we put aside the consideration of the lower orders of living creatures, such as thallophyte plants, protozoan animals, etc. The psychological study of these creatures is far more difficult and more delicate a matter, and it is only very recently that it has been undertaken. But the new idea, which it has revealed are of great importance: They have enabled us not only to perceive the full extent and the universal application of the law of the alternation of generations but also to gain more precise information concerning the phenomena of fecundation (the formation of the egg, on the one hand, and of meiosis (the formation of spores), on the other; and as we have seen these two phases constitute the critical stages of development of all living creatures.

"To begin with the general or universal application of the law has been confirmed. Among the thallophytes (algae and fungi) many cases are known in which the scheme of development is of integral application. The red marine algae, and the ascomycetes fungi (Morillas Pezizas) fall strictly under the general law, *i.e.*, the sporophyte, the product of a normal fecundation lives as a parasite upon the gametophyte; it forms one or more so-called 'fruits' which produce spores; finally, these spores are produced by meiosis to the number of four (or two or eight or sixteen) in mother cells analogous to tetrad cells.

"Thus far we have come across nothing which is not practically normal—and here again as in all the creatures of which we have spoken the two branches or phases of the cycle, although morphologically distinct are not separate. And not only are they contiguous but the *sporophyte phase lives as a parasite upon the gametophyte phase*, just as we have seen was the case in the mosses and, likewise, at least in the beginning, in the ferns and higher plants. Consequently it may be said that in all the creatures with which we have been thus far concerned the gametophyte phase which furnishes nutrition and the sporophyte phase which acts as a parasite are, at least for a certain length of time united with each other so as to form a body which may be considered a unit; this is the rule which governs the case and which has thus far been absolute.

BROWN ALGAE AND MYXOMYCETES FUNGI

"But let us now consider the brown marine algae (Cutleria-Laminaria) and the myxomycetes fungi (Didymia) which form an exception to this rule.

"*Brown Marine Algae.*—The cutleria, attached to the rocks of the shore produce gametes and eggs: these eggs floating freely in the water do not develop on the mother plant. After having wandered for some length of time at the whim of wind and wave, they attach themselves to a rock and germinate forming an embryo which is very different morphologically from a cutleria and which leads an existence entirely independent of the mother plant. But this embryo is a well-known organism which was long ago described by botanists under the name of Aglaozonia. The aglaozonia in their turn are incapable of producing gametes, but produce spores on the contrary, and, furthermore, each of these spores upon germination gives rise to a cutleria thallus. The discovery of this fact makes the matter clear: the cutleria and the aglaozonia are not two different species of algae as was long believed but merely the two phases of the vital cycle of the same plant.

"The same peculiarity is found among the Laminaria. These giants in the world of marine flora produce only spores. These spores produce upon germination not laminaria but microscopic thalla. So small that they long remain unperceived; from these thalla gametes and eggs are born which produce new laminaria.

"*Myxomycetes Fungi.*—The same fundamental development takes place among the myxomycetes fungi but after a very different mode. A didyma lives upon decaying wood; it produces small 'fruits' abundantly filled with spores. Each of these spores gives rise upon germination to a very singular thallas. This thallas is at first a small cell lacking a rigid envelope and consisting, therefore, merely of a bit of naked protoplasm having a nucleus and known as a 'myxamoeba.' This myxamoeba grows and divides into myxamoeba daughters which part company; then these undergo division in their turn and so on indefinitely, so that the thallus of the didyma is a fragmentary and scattered thallus composed of innumerable free and mobile cells all similar to each other. At a given moment some of these cells become gametes and fuse together in couples to form eggs which are likewise naked and mobile. The egg grows in its turn without dividing its mass into fragments but dividing its nucleus repeatedly; it thus forms a 'plasmod' which is transformed later into a spore bearing fruit. The gametophyte formed of *dissociated myxamoebas* preceding from the germination of the spore, and the sporophyte in the form of an *undivided plasmod* produced by the germination of an egg constitute the two phases, entirely independent of each other which compose the cycle of development of a didyma.

THALLOPHYTE PLANTS

"We see, therefore, that the thallophyte plants—and the same thing is true of certain of the lower animals—furnishes us many examples in which the two phases of the development are represented by two entirely separate, *dissociated* organisms leading an existence independent of each other. These organisms which a superficial examination might cause one to classify as two species quite distinct and even belonging to taxinomic groups quite remote from each other, are therefore in reality the two successive and dissociated phases of the same living creature. Indeed it is worth while remarking that it is infinitely probable that among the numerous forms

of the lower plants and animals, many should really be coupled together as being merely the two phases of development of the same creature.

The existence of these plants which develop in dissociated phases such as the cutleria raises an interesting question, namely, whether the forms marked by dissociated development are to be regarded as more primitive than those in which the two phases remain *associated* or whether, on the contrary, they are to be looked upon as derivatives of the latter. In our opinion it may be accepted as a principle that the parasitic life is acquired secondarily, being subsequent to a mode of life which was originally independent. If this is true we are obliged to believe that a cycle of development with a parasitic sporophyte is merely a subsequent adaptation of a cycle of development marked by an independent sporophyte. Accordingly the case of the cutleria and of many other thallophytes appears to represent the original mode of life from which have been derived later the various modes of development of the intermediate plants and the higher plants.

"Another thing supports this idea: In the cutleria, as in many other thallophytes, the gametophyte and the sporophyte appear to be practically equal in importance, not only as regards their respective sizes but with respect to their duration of life and their morphological differentiation. Furthermore, it is very satisfying to the mind to believe that this state of balanced equilibrium between the two phases of the life of the living creature is the original state from which have been derived those cases where there is an enormous disproportion between the two phases.

"Furthermore, from the primitive type having practically equal phases there are derived on the one hand those forms in which the gametophyte is of the most importance (including numerous ascomycetes fungi, red marine algae, hepaticus mosses) and, on the other hand, those forms in which the sporophyte is preponderant (as in certain thallophytes and higher orders of plants). Hence the double phyllum, which in the eyes of evolutionary biologists, embraces the entire world of plants, in spite of their high degree of differentiation.

"At all events, whatever may be thought of these theoretical views the fact remains that among certain of the less highly evolved plants the two phases of the development exhibit, on the one hand, a sort of parity or equivalence which has ceased to exist among the more highly evolved plants, and on the other hand, a reciprocal independence as regards their mode of life, of which it is no longer possible to find a trace in the higher and intermediate plants, or even in many of the lower orders of plants.

TWO SEXES IN THE THALLI OF FUNGI

"Finally, the study of certain fungi, including the ascomycetes (Pezizas of the genus pyronema, etc.) or Basidiomycetes (Coprins, Uredinea, etc.) has thrown fresh light upon the essential nature of the phenomena of fecundation and of meiosis.

"*The Coprins.*—The Coprins are, as their name indicates, fungi which grow in abundance upon manure; when mature the gills dissolve into a sort of inky fluid and the spores are formed four by four at the expense of the tetrad mother cells, known as 'basids,' which are found in great numbers upon the gills of the lower surface of the fungus.

"But in the Fimicolus or dung-growing coprin, the spores, although similar in appearance are really different in nature, since when they germinate they produce two kinds of filament bearing thalli, which may be designated by the signs plus (+) and (—). These thalli are composed of filaments formed of cells having a single nucleus. A (+) thallus when cultivated alone, even in the most nutritious medium develops abundantly but continues sterile, and the same thing is true of a (—) thallus, but if we form a mixed culture of both kinds either by sowing in the same medium (+) spores and (—) spores or, by mingling (+) thalli with (—) thalli, certain fructifications occur, *i.e.*, we obtain these little fungi on the lower surface of which basids and spores are formed.

"*Sexually Different Thalli.*—From this we are bound to conclude, in accordance with all the teachings of biology that the two kinds of thalli, though so similar in appearance are in reality *sexually different*, and that upon their conjunction there occurs a fecundation which results in the development of the fruit which bears the spores.

"But let us inquire what really takes place in the mixed culture. We observe two cells, one of which belongs to a (+) thallus and the other to a (—) thallus, form a junction by means of anastomosis; their protoplasms become fused together and their nuclei approach each other without becoming fused. This sexual approach of the two nuclei toward each other creates such a bond between them and causes them to be so closely associated in their later evolution, that the name of *conjugated nuclei* or of *dicaryon* has been given to them.

"Bi-nucleated cells thus formed germinate by thrusting forth a filament embracing both nuclei: the latter approach each other, arrange themselves side by side and *undergo division in a parallel and simultaneous manner.* The filament continues to grow and the dicalyon to undergo division in the same manner, and this continues indefinitely until first the fungus cap is formed and then the basids, *i.e.*, the tetrad cells which are the mothers of the spores.

"This action must be interpreted as follows: The fusion of the (+) and (—) cells with the formation of a dicalyon is evidently a process of fecundation and the filaments constituted by the dicalyon cells represent the sporophyte phase. In the egg the two nuclei of different signs, the '*paternal*' and '*material*' as they may be called, remain morphologically distinct in spite of their intimate association in the dicalyon. In the same way the chromotines of paternal and maternal origin continue to remain distinct during the course of the divisions of the egg and the ulterior formation of the sporophytex. Finally, it is in the mother cell of the spores at the very moment when meiosis is about to occur, that the two conjugated nuclei finally becomes fused into a single nucleus and that the paternal and maternal chromotines become intimately mixed.

"The conjunction of two gametes accompanied by a fusion of the protoplasms and a simple approach toward each other without fusion of the nuclei is by no means peculiar to the coprin. The pezizas of the genus pyronena exhibit the same peculiarity bringing into operation highly differentiated sexual organs. And in the animal kingdom itself we may cite the case of the Copepods in which the nuclei are of paternal and maternal origin, remain distinct not only in the fertilized egg but also in the tissues of the embryo which results from a process of division which takes place in the said egg, and doubtless, also up to the very stage in which the chromatic reduction occurs.

LONG SOUGHT ANSWER TO A MUCH VEXED BIOLOGICAL PROBLEM

"We may, therefore, hold it to be solidly established that the interpretation given above is correct, and if this is true the case of the Basidiomycetes assumes considerable theoretical importance and enables us to explain the question which has hitherto remained highly obscure.

"Up to the present time, in fact, biologists have long debated whether the *apparent* fusion of the nuclei, which is the rule which governs fecundation in plants and in animals, is really an actual fusion involving the intimate mingling of the paternal and maternal chromotines—or whether, on the contrary, the paternal and maternal chromosomes remain distinct until meiosis occurs. The explicit case of the Basidiomycetes given above proves without doubt that the second hypothesis is correct.

"Since this is the truth of the matter, in the case of the Basidiomycetes, we are obliged to assume in default of convincing argument, to the contrary, that the same thing is true among other plants in which the phenomenon is less clearly defined and as it were more condensed.

"We thus arrive at the conclusion that as a general thesis

and among animals as well as among plants the following theory of fertilization is correct:

"1. At the moment of fecundation there is merely a simple approach toward each other of the chromatic rods of the two gametes;

2. In the course of the development of the sporophyte the two chromosomes of a nucleus remain distinct and it is not until meiosis occurs that the intimate mingling of the paternal and maternal chromatines takes place, this being probably accomplished by the fusion in couples of chromosomes of different sex. This latter hypothesis likewise has the merit of furnishing a ready explanation of the numerical reduction which causes the number of chromosomes to be divided in half at the moment of the formation of the spore.

"The question still so hotly debated after the individuality of the chromosomes in the nucleus in a state of rest is answered in the same manner: it is impossible to believe, in fact, that the chromatines of different sex would continue to remain distinct were it not that the rods which bear them retain their individuality during the course of the numerous fluctuations of the life of the nucleus. And if we accept this view of the persistence of individuality in the chromosomes of the sporophytic nuclei, we must undoubtedly accept it as applying also to the nuclei of the gametophyte."

CONCLUSION

The preceding observations have shown how suggestive is the study of the lower order of plants and how valuable are the data which they furnish to natural history. It is by the study of these humble organisms that we have been able to elaborate this great law of the alternation of generations which governs the development of the entire organic world; it is by such study likewise, that it has been given us to procure a profounder knowledge of the phenomena of fecundation and of meiosis; it is to this likewise that we are indebted for the most topical proof of the persistence of the individuality of the chromosomes in the quiescent nucleus. All these results are due to the fact that these modest organisms present in a clearly defined and obvious form an entire series of phenomena, which in other living creatures are susceptible of observation only in a greatly shortened and condensed form which is infinitely less evident to the eye.

HOW YOUNG PLANTS DEFEND THEMSELVES AGAINST STARVATION

During the last few years a great deal of research has been devoted to the powers possessed by men and animals to resist starvation, and the subject has acquired an exceedingly keen interest of late, because of various tragic conditions and circumstances abroad. Strange to say, however, there has hitherto been but little study of a similar phenomenon in plants. Yet since plants form the ultimate food supply of animals it is obviously highly important that the conditions governing their nutrition and their powers of resistance to malnutrition should be known. The well-known French botanist, M. Henri Coupin, has recently, we are glad to say, made a special study of this subject and the results of his observation were laid before the French Academy of Sciences at their session of September 13, 1920.

M. Coupin devoted his attention to seedlings reared in the dark and, therefore, deprived of the carbon of the atmosphere, being unable to assimilate it by means of chlorophyl under these conditions. The only nourishment given the young plants was distilled water. They were allowed to remain after germination in a dark room until they perished, thus affording an opportunity to note the time during which they were able to resist this practical starvation. M. Coupin remarks that it is somewhat difficult to determine the exact time of the plant's death since it is rather hard to distinguish between a seedling which is already dead and one which is at the point of death, and since, moreover, among the same lot of seeds, which are quite identical to all appearance, some produce seedlings which live longer than those produced by others. With this reservation he presents the following table, which should be of great interest not only to botanists but to practical agriculturalists.

Plants observed.	No. of days required to produce death.
Nut-bearing pine	60 days of inanition
Pumpkin	46 " "
Winter vetches	44 " "
Lentils	40 " "
Marvel of Peru	39 " "
Peas	33 " "
Haricot beans	32 " "
Sunflower	30 " "
Gray buckwheat	25 " "
Radish	24 " "
Nasturtium	23 " "
Spinach	22 " "
Tomato	21 " "
Beet	20 " "
Common cress	18 " "
Mustard plant	18 " "
Provence Lucerne	15 " "

As we see, this table shows a very remarkable variation in resistance ranging from a power to live for two months on water alone, to a resistance which succumbs in one fourth of that time. These differences obviously depend, according to M. Coupin, upon the more or less resistant nature of the organism itself, and in particular upon the abundance and the character of the reserve materials at its command.

THE DUMB CANE

One of the most attractive of our native wild flowers is the Jack-in-the Pulpit, whose graceful spathe pierces the mold of our forests in early spring. In the fall this spathe has withered and the central spadix—the "Jack" of the spring—is covered with brilliant red berries, not only handsome but very edible in aspect—but in aspect alone. The writer well remembers tasting one of them tentatively, merely inserting her teeth into one of the scarlet fruits—for several hours thereafter her tongue felt as if it were serving as a pincushion for a thousand tiny red hot needles! The Jack-in-the Pulpit, in fact—or Indian turnip as it is also known—belongs to the family of the *Araceae*, which are characterized by an extremely acrid and poisonous juice. Most of this family, of which there are something like a thousand species, are natives of the tropics, and in these this acrid principle is apt to be highly toxic. One, indeed, the *Dieffenbachia seguina*, found in the West Indies and in South America, is popularly known as the *dumb cane*, because if it is chewed it causes the tongue to swell so that the victim is unable to speak. However this poison can be removed by cooking or by washing, and many of the species bear tubers which abound in starch, and furnish a wholesome and nutritious food when properly prepared. The Indian turnip is so called, in fact, from the fact that it was eaten by certain tribes. The handsome plant known as the Wake-robin, the cuckoo-pint, and sometimes picturesquely termed "lords-and-ladies" (the *Arum maculatum*) is used for making arrow root.

Another species which is extensively cultivated in tropical countries for food is the taro. The best-known examples of this family in our own temperate zone are the Jack-in-the Pulpit, the skunk cabbage, as beautiful to behold as it is offensive to come near, and the sweet flag or calamus.—*May Tevis.*

INDIAN USES OF KELP—CORRECTION

In our issue of February last we published an article entitled "Indian Uses of Kelp." Our attention has been called to a typographical error in the name of the author. The article was credited to J. C. Leachman instead of J. D. Leachman.

GATHERING ROSES AT RAHMANLARI, ON THE SUNNY SLOPES OF THE BALKANS

The Attar of Roses

French and Bulgarian Methods of Producing the Essential Oil of Rose Petals

By May Tevis

HAD nature confined that royal flower, the rose, to a remote and almost inaccessible region of the earth, instead of lavishing it by the wayside in nearly every country upon the globe, men would travel thousands of miles and brave untold hardships and dangers for a glimpse of its incomparable perfection of color, form and grace. But lavishly as it is spread at the feet of mankind, nothing can stale its beauty and its charm. In every nation and in every age poets have made it the theme of their loveliest lays. In Persia the romantic fancy of generations of poets linked its name with that of the most enchanting of birds, the shy nightingale, and in their primeval *naïveté* they saw nothing incongruous in making the bird the romantic lover of the blossom, pouring forth its praises under the star-filled skies.

But supreme among the charms of the rose is its exquisite and haunting fragrance, a fragrance at once delicate and powerful, and so persistent that it may cling for months to a fabric, the page of a book, or the shattered fragment of a vase. Small wonder that the ancients felt the perfume to be the soul of the rose, or that they sought some means of holding it fast when the blight of winter had withered the lovely petals of the flower.

It was sought by various means to accomplish this devout purpose. Layers of petals interspersed with layers of salt and spices—the famous potpourri of our grandmothers and their forbears—was one method. Another was the making of rose water.

It is not known positively who first discovered the method of extracting from the petals the pure oil or attar of roses—this by the way is also known as the otto of roses, but since the late European unpleasantness that word somehow has a disagreeable connotation, so we shall avoid it in this article! This oil, or attar, or essence, is produced by distillation and it was probably the Arabs who discovered this art and introduced it into Europe. There is an old book in the National Library in Paris, from which we learn that during the reign of the Caliph Mamoun (810 to 817 A. D.) in Persia, the province of Faristan was required to pay an annual tribute of 30,000 botties of rose water to the treasury of Bagdad. But while the essential oil or attar was described by Rossi in the latter part of the 16th century, it was not discovered or rediscovered in Persia until 1612, and then by accident, according to the pretty story told in the *Annals of the Mongolian Empire*, an old work written by a Venetian physician named Manecci. As the tale runs the Princess Nour-Djihan being betrothed to a visitor from Paradise, the Prince Djihan-guir, arranged a fête in his honor to celebrate the festival of the New Year. Being minded to show her skill in the womanly arts of the day, she and her maidens prepared for him a gift of rose water. But not content with offering a few flasks, the princess displayed the lavishness of her affection and her wealth by filling with the precious fluid the bed of an artificial stream, which she caused to be made within her luxurious garden. Here as the great lady and her lover walked to take the air they observed that the surface of the rose water beside whose channel they were strolling, was covered with a delicate oily film. When this was collected and examined the royal couple and their court were enchanted to find that their vials held the very soul of the rose, its essence.

But while the rose gardens of Persia and the precious attar distilled from their petals will never fade in our memory, the great bulk of this valuable product is now made in the Balkans. It is Bulgaria that is today the Rose Garden of the world. The earth beneath and the air above the sunny slopes of the Balkans contain the elements most fitted to be transformed by nature's alchemy into the miracle of the rose. The soil on these slopes is extremely fertile, being composed chiefly of crumbled syenite. The chief center of the industry is Kazanlik and around this town stretch thousands of acres covered with roses, the area under cultivation lying between the 24th and 26th degrees of longitude east and the 42nd and 43rd degrees of latitude north. Besides their advantages of sun, soil, and air, these Balkan slopes furnish two other indispensable means for the work of distillation; water and fuel.

In the height of the season as far as the eye can reach it is greeted by gorgeous masses of color from the rich crimson blossom of the *Rosa Damascena* grown in fields bordered by hedges of white roses, the *Rosa Alba*. This picturesque arrangement of contrasting colors is not due to any esthetic sense on the part of the Bulgarian grower, however; it is due alas to a very sordid motive! While the white rose is much poorer in perfume than the damask rose, it is richer in the chemical substance called stearoptene, and this substance, as we shall see, facilitates fraud by making it easier to adulterate the final product.

The flowers are gathered before they begin to open, just when Aurora is spreading drifts of rose petals upon the sky. In no case does the picking of the flowers continue later than 10 or 11 o'clock in the morning, unless the sky be overcast with clouds, since it is of vital importance that they should not be gathered while the heat of the sun is upon them. A properly planted garden, well taken care of, yields about 100 pounds of flowers per day for about three weeks. The roses are carried to some one of the many distilleries in the district as quickly as possible. It is considered imperative to distil them the very day they are gathered, since if kept for even 24 hours the oil is less fine in quality.

A MORNING'S GATHERING OF ROSES IN A FACTORY AT RAHMANLARI

The pile averages a foot in thickness and weighs 10,000 lbs.

THE METHOD OF DISTILLING

Most of the distilleries are rather rough, being hardly more than wooden sheds. The stills are arranged in rows as shown in our illustration. They consist of copper alembics about 3 to 5 feet in height, resting on a furnace built of bricks. The average contents of each still is about 20 gallons, the charge usually being 10 kilos of flowers and 75 liters of water.

The condenser is a straight or worm tube passing through a vat of water, into which cold water continually runs. A brisk fire is kept up for an hour to an hour and a half, and when ten liters of liquid are obtained the fire is drawn. At times 15 liters are distilled over, but the result is an attar containing a larger amount of stearoptene. The still is then opened and the spent petals, or rather flowers, for the green parts are seldom separated, are thrown away, and the residual hot water is returned to the still with cold water to make up the 75 liters, with a fresh charge of flowers. This operation is repeated until, as a rule, 40 liters of rose water have been collected. These 40 liters are now distilled, and the first 5 liters are collected in a long-necked flask. The residual 35 liters are used for distilling fresh flowers. The 5 liters distilling over are cloudy, and the oil drops gradually rise and collect in the neck of the flask. When it has all risen, it is removed by a small tin funnel with a tiny orifice for the water to be drawn off. The yield is variable, a warm humid spring with intervals of strong sunshine being more favorable than an uninterrupted dry season. The average yield in Bulgaria is about 1 kilo of attar from 3,000 kilos of rose leaves.

ROSE PETALS BEING PLUCKED IN ONE OF THE FACTORIES AT GRASSE, FRANCE

CHARACTERISTICS OF THE ATTAR

Pure, carefully-distilled rose oil is at first colorless, but soon turns yellowish; this, however, applies only to Bulgarian oil; French and Saxon rose oils have a greenish color. Its specific gravity is between 0.830 and 0.890. It consists of a liquid oil and a stearoptene, the content of the latter varying very much; it is a pure hydrocarbon, odorless, of specific gravity 0.840 to 0.860, and distills at 572° F. Hence it is lighter than the elæoptene to which alone the scent of rose oil is due. Rose oil generally congeals between 50° and 60° F., though sometimes at a higher or lower degree, according to its content of stearoptene. While some oils require the cold of winter for congealing, others are in the heat of summer either entirely solid, or form a fluid filled with many crystals. The odor of rose oil is peculiarly honey-like, and too strong to be agreeable, its entire deliciousness being only developed by great dilution in water or alcohol, or by distribution upon large quantities of solids such as fats, soaps, etc. In alcohol it dissolves with greater difficulty than all other volatile oils, 1 part of it requiring for solution 140 to 160 parts of alcohol of 0.815 specific gravity.

The larger or smaller content of stearoptene in rose oil seems to be dependent on climate, the quantity being greater the lower the temperature. The oil from the coldest and highest regions of the Balkans is richer in stearoptene than that from the lower and warmer regions.

The genuineness of rose oil is generally judged by its odor, its capacity of congealing, and the manner of its crystallization. The odor is the best test, but requires much experience and especially reliable pure standard samples for comparison. The capacity of congealing at certain conditions of temperature is also a requirement of genuine rose oil, but this property varies greatly and is subject to different influences, so that a fixed standard at which pure rose oil must congeal cannot be established. But the quality of a rose oil does not rise with its greater capacity to congeal, since only the liquid oxygenated portion is frequent. The well-known German firm, Schimmel & Co., have put on the market a liquid rose oil freed from stearoptene which can be highly recommended for finer alcoholic perfumes. It remains fluid at

32° F., but in a cold mixture congeals to a gelatinous mass, and hence is not absolutely free from stearoptene. It has an extremely fine and powerful odor, and when dissolved in alcohol does not give the disagreeable crystalline separations of the ordinary rose oil, which are disturbing, especially in making extracts.

For the insulation and determination of the stearoptene in rose oil, Schimmel & Co. proceed as follows: Heat 50 gr. of oil together with 500 gr. of 75 per cent alcohol to from 158° to 176° F. In cooling the stearoptene separates nearly quantitatively. Separate it from the fluid, treat it again in the same manner with 200 gr. of 75 per cent alcohol and repeat the operation until the stearoptene is entirely free from odor. Two treatments of the crude stearoptene are generally sufficient. In this manner Schimmel & Co. obtained from 1887 German rose oil 32½ per cent stearoptene, from 1888 German rose oil 34 per cent, from 1887 Turkish rose oil 12 to 13 per cent, and from 1888 Turkish rose oil 14 per cent.

AN OUTDOOR STILL IN SOUTHERN FRANCE

The chief adulterant used by the Bulgarians is the so-called geranium oil, which is really ginger-grass oil from India brought by way of Arabia to Constantinople, and prepared for adulterating rose oil by treatment with lemon juice and bleaching in the sun. The brand is generally made by sprinkling the ginger-grass oil thus prepared upon the rose leaves before distilling. The general characters of this oil are so similar to those of rose oil that detection is very difficult, so that during the distilling time large buyers and exporters of rose oil are forced to pay confidential native agents who constantly move around in the distilling regions and report where distillation has been carried on honestly, and where the ginger-grass oil bottle has been seen. However, the prepared ginger-grass oil is frequently not even distilled with the rose leaves, but simply mixed with the finished rose oil.

Whether a rose oil is free from geranium or ginger-grass oil is tested in Bulgaria, according to Christo Christoff, by the freezing method, which is, however, unreliable. It is based upon the fact that an addition of geranium oil reduces the congealing point of rose oil. Pure Bulgarian rose oil congeals at from 63.5° to 68° F.; by the addition of geranium oil, the same oil congeals at 61.25°, 59°, 56.75°, or at a still lower temperature, according to the quantity added. The buyer when purchasing oil carries with him two basins, one containing hot and the other cold water which he mixes in order to obtain a fixed temperature, the operation being controlled by a Réaumur thermometer. In the water thus prepared he completely submerges a 20 gram flask containing 15 gr. of the oil to be tested. In three minutes, needle-like crystals of the separating stearoptene must appear, and in ten minutes crystallization must be complete. According to the congealing point thus established, the produce is paid for. Oil congealing below 59° F. being evidently adulterated is rejected and bargained for at a special price.

Many attempts have been made to make this congelation appear within the limits of temperature permitted, paraffin which dissolves well in rose oil being formerly frequently added. In such case the oil may congeal at from 65.75° to 68° F., but the crystals are opaque, dirty yellow, and dissolved to a turbid paste which collects on the surface. The simplest method is to distil white roses with the red. The product has not so fine an odor as that from red roses alone, but is richer in stearoptene. Such oil, which, unadulterated, congeals perhaps at 68° F., can by the addition of geranium oil be reduced to from 63.5° to 65.75° F., thus keeping within the limits permitted.

Numerous attempts have been made to find a rapid and sure way for the detection of geranium oil in rose oil, but thus far in vain. Attention must also be drawn to the fact that

A BATTERY OF NATIVE STILLS USED FOR EXTRACTING THE ESSENTIAL OIL OF THE ROSE

the adulterant is frequently itself adulterated ,with oil of turpentine before being sold to the distillers of rose oil.

Besides the above-mentioned ginger-grass oil, the actual geranium oils from *Pelargonium odoratissimum* and *P. roseum*, as well as rose-wood oil, sandal-wood oil, spermaceti, paraffin, and fat oils have been used to adulterate rose oil. But the geranium oils having a by-odor of lemon oil by which their presence can be readily detected are not suitable. Neither are rose-wood or sandal-wood oils; such adulteration would be so clumsy as to be immediately recognized. Attempts to adulterate rose oil by the addition of a fatty crystallizable body together with another volatile oil fail on account of the characteristic properties of *rose-oil stearoptene, which resembles no other body at present known.* While rose-oil stearoptene is lighter than elæoptene and entirely volatile, spermaceti possesses essentially different qualities. It does not form such long and spcifically light crystals as rose-oil stearoptene; hence it readily separates on the bottom and on shaking exhibits a peculiar iridescent loamy formation. Furthermore it melts at 122° F., and, not being volatile, leaves, on heating a greasy stain upon paper, while the stearoptene melts at 95° F. and, on heating, volatilizes completely without leaving a stain.

HOW TO TEST ROSE OIL

If a rose oil is to be tested, expose the bottle containing the oil to a moderate heat until the contents are entirely liquid; then gently shake the bottle in order intimately to mix the elæoptene and stearoptene. Now pour some of the oil into a cylindrical glass flask of 20 to 40 cubic centimeters' capacity and allow it to congeal; then, while heating in the hand observe how the rigid portions act in liquefying. These rigid, crystalline portions should be transparently clear and should float, while melting in the upper layer of the fluid. Hence, when the fluid be again allowed to congeal, the crystals should appear within the upper half of the oil. The above-mentioned volatile oils partially lack the property of separating a stearoptene in crystals from 33.8° to 50° F., and though they may have a rose odor, it is not the mild, fragrant odor of genuine rose oil. To recognize the latter, Guibourt makes use of pure concentrated sulphuric acid. Stir together in a watch-crystal an equal number of drops of the oil and of the acid; pure rose oil preserves its characteristic odor, while the foreign oils exhibit a disagreeable odor even when mixed with genuine rose oil.

French attar has a clear and penetrating perfume similar to that of the freshly cut flower.

In France only steam stills are used, to the exclusion of apparatus used with open flowers, which in burning the flower somewhat imparts to the essential oil a slightly burnt odor from which the French attar is free.

The characters of attar of rose vary considerably according to the locality in which the plants are grown, and also in one locality from season to season according to climatic and other conditions. All these factors must be taken into consideration in forming an opinion on attar of rose, and it must be remembered that no published figures can be accepted as final or exhaustive. The following may be taken according to Parry as being typical, however, of the best attars produced in various localities:

BULGARIAN ATTAR OF ROSE

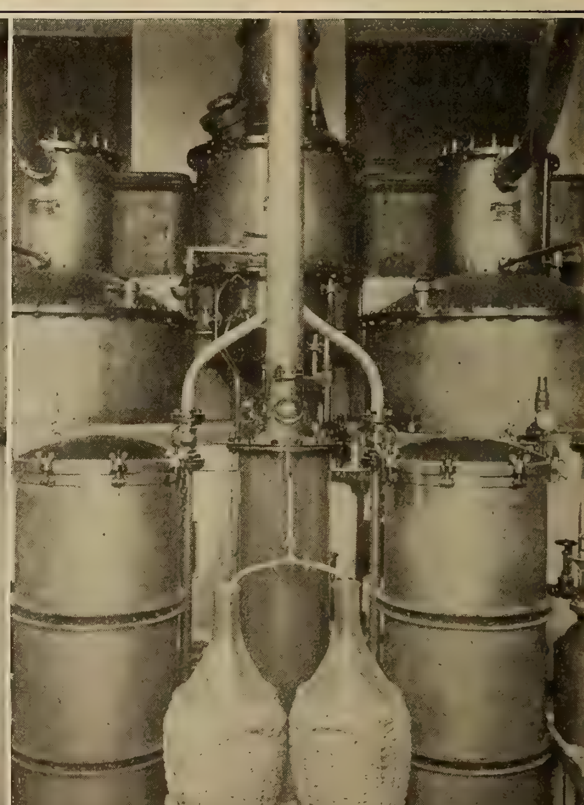
Specific gravity at $\frac{30°}{15.5}$	0.849 to 0.858
Optical rotation	—1°30′ to 1.4650
Refractive index 25°	1.4580 to 1.4650
Melting point	19° to 22°
Total alcohols	68 to 78 per cent
Citronellol	28 to 34 per cent
Acid value	0.1 to 0.3
Ester	0.7 to 1.2
Stearoptene content	15 to 20 per cent

FRENCH ATTAR OF ROSE

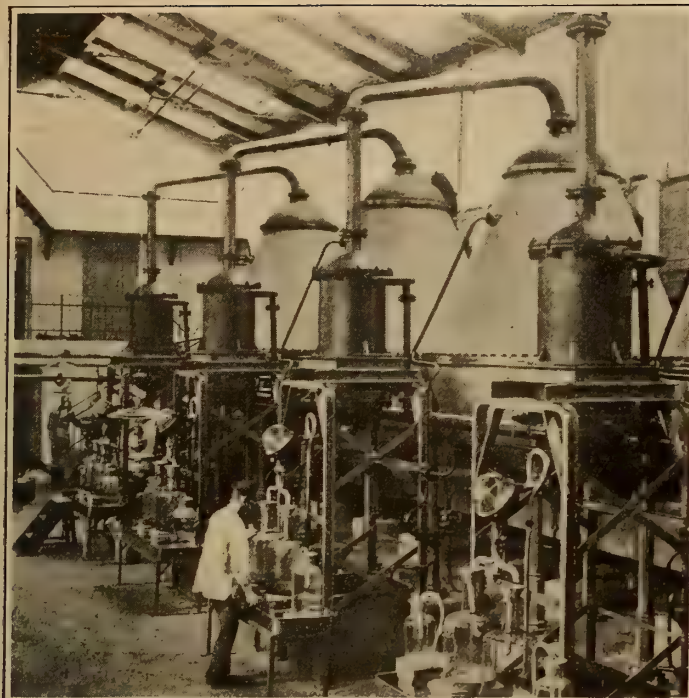
In France numerous different roses are distilled, each yielding its own characteristic attar, so that the resulting products will vary according to the percentage of each given rose in the distilling material.

In 1904 Jeancard and Saltie (*Bull. Soc. Chem. de Paris*, 1904, 934) published a paper dealing with the analysis of

TANKS OF ROSE WATER AND BOTTLED ATTAR OF ROSES



A MODERN STILL IN A BULGARIAN FACTORY



STILLS IN A FACTORY AT GRASSE

ROSE WATER IN THE CELLAR OF A FACTORY AT GRASSE

attar of roses. They distilled a sample from the sepals only of *Rosa centifolia*, and found it to have the following characters:

Congealing point	8°
Stearoptene	51.13 per cent
Specific gravity	0.8704 at 15°
Rotation	—41°
Melting point of stearoptene	14°
Acid value	6.12
Ester	16.28
Total alcohols	13.99 per cent
Citronellol	13.56 per cent

(*We are indebted for these figures as well as much other valuable information to the admirable volume by Parry on "The Chemical Properties of Perfumes," published in 1918.*—EDITOR.)

THE CARE AND AGING OF PERFUMES

By L. J. ZOLLINGER

THE tanking and conservation of perfumes involves a very careful study of the effects upon the product of the various metals or other materials of which tanks, pipes, funnels, funnel supports, pumps and other paraphernalia are made. Discoloration and deterioration, due to oxidation, too frequently result from ignorance of this elemental consideration.

As a case in point, let us take monel metal, once regarded as the alloy *par excellence* for the purposes of manufacturers of certain pharmaceutical preparations, to store essence of pepsin, for example. It was later discovered, to the chagrin of the industry generally that monel metal contains iron, which is a dire threat to many modern perfumes containing synthetic products, such as Indol, Methyl Anthranylate, Heliotropin, Vanillin, compounds of Iso-Eugenol or any of the Salicylates.

Galvanized iron is bad, as is so-called agate ware. Enamel would be satisfactory if absolute perfection of quality were to be had in this country. Aluminum containing trace of iron is taboo. Copper should not be employed unless heavily tin coated and, even then, it should be relined once a year, and be so constructed as to permit of convenient inspection.

Earthenware of good quality makes excellent containers. Some perfumers here and abroad have used silver-lined tanks with satisfactory results. Silver-lined faucets are desirable. Brass corrodes or oxidizes and is therefore unsuitable. The top opening of the tank should be hermetically sealed.

Glass-lined tanks are most desirable for the perfumer's every purpose. They should be thoroughly cleaned and carefully inspected before the mixing of a new batch.

Rubber gaskets and washers should be employed with utmost discretion, since they dissolve in alcohol and, especially, in concentrated perfumes. Use rubber washers only where they do not come in contact with the extract, as on the outside. A ground steel V-joint is always efficient, since it can be made very tight and thus remove all danger of evaporation.

In trans-vasing, as in storing, extreme care is demanded. Never use rubber tubing, for the same reason as given in relation to rubber gaskets. Block tin or silver is appropriate to the purpose. Store the alcoholic tinctures—Musk, Civet, Ambergris—in glass demijohns away from the light and in a moderately warm temperature. Never make or store Orris Root tincture in tin percolators and never store it in tin tanks —the extreme of folly.

Don't—if you can avoid it—allow a small quantity of a perfume to remain long in the tank. This makes for oxidation, decomposition and deterioration. It is considered good practice, for example, where the original batch is 100 gallons, to draw off and place in a suitable container the final 10 gallons.

No experienced perfumer needs to be warned to arrange his store room of bulk perfumes in a cool, dark place, kept scrupulously clean and in apple-pie order.

The aging process depends altogether on the composition of the product. The heavy natural bouquet odors improve tenfold by aging, whereas many new-type odors based upon artificial ingredients will not stand aging. The quicker the latter named perfumes are bottled and sold, the better.

Discoloration frequently does not take place immediately upon contact with the wrong metal but may occur long afterward, when the goods are for sale in the retail store. A discolored product is absolutely fatal to the sale. It should be crystal-clear, well filtered, brilliant. Tint it if necessary.

When pomades were so extensively used it was recognized as vital and necessary to chill and filter the washings of flower bases. Owing to the ease in using liquid flower essences made by the volatile-solvent process, perfumers are becoming somewhat lax in this respect. But the perfumer who plays sure will test his finished product by chilling a small quantity from the batch to, say 30° to 32° F. Then and only then can he be assured that there will be no deposit in winter.—*Montreal Pharmaceutical Journal*, Jan., 1921.

What is Manna?

Modern Varieties Compared with the Biblical Food

By T. A. Marchmay

A VERY absurd report has recently gone the rounds of the newspapers, purporting to be a consular report to the effect that "manna still falls from the skies like dew and is collected and eaten as in the days of the ancient Hebrews, but it only survives the night when it falls upon the oak tree; on other trees it immediately withers away."

Because of the wide publicity this statement was given it seems worth while to correct its errors and state the facts, which happen to be quite interesting.

To begin with, dew itself does not fall from the sky but is produced by the condensation of moisture. In the next place there is no direct connection whatever between dew and manna.

Manna is the term applied to the dried sap of certain trees containing a chemical compound known as mannite. It is produced on a commercial scale in modern times, most of it coming from Sicily. It is shipped to drug supply houses in various parts of the world. The writer has bought and eaten it within the last few days. It was obtained in one of the well-known chain drug stores.

The manna that comes from Sicily is a sweet substance that exudes from incisions in the stems of *Fraxinus ornus* and other species of ash. During July and August incisions are made in the trunks and larger limbs of the trees, and if the weather be warm the manna begins to ooze from the cuts and harden into lumps or flakes which are removed by collectors. Manna is a light porous substance of a yellowish color, not unlike dried honey. There are different qualities found upon the market, which vary in their purity and composition. Flake manna is obtained when there is an abundant flow from the upper incisions. It dries into flat pieces or tubes and differs somewhat in composition from the other varieties. Small, or talfa, manna occurs in tears from the lower incisions and is less crystalline and more gummy. Fat manna is brownish, viscid, non-crystalline, and is usually full of fragments of bark and other impurities. Manna is largely used in medicine as a laxative, demulcent, and expectorant, and is commonly administered with other medicines, as senna, rhubarb, etc. Its constituents, as reported by many investigators, are mannite 60 to 90 per cent, glucose, mucilage, fraxin, resin, etc. In addition to its value in medicine, manna has been extensively used for food, its value for this purpose depending upon the carbohydrates present.

In addition to that produced by various species of ash, manna or substances resembling it are excreted by many other species of plants. In Australia various species of Eucalyptus produce what is called manna or lerp. This saccharine substance is said to be without the laxative properties of true manna and is eaten as food. Similar substances are obtained in Australia from the tea tree (*Leptospermum scoparium*), sandalwood (*Myoporum platycarpum*), and Australian blue grass (*Andropogon unnulatus*). During a famine in India a manna-like substance was exuded in sufficient abundance from a species of bamboo (*Dendrocalamus strictus*) to form an important food supply in some districts. It did not contain any mannite, the principal characteristic of true manna. Similar substances are obtained from the common larch of Europe (*Larix decidua*), the substance being known as Briancon manna; from *Quercus vallonea*, called Armenian manna from *Alhagi camelorum*, camel's thorn; tamaris manna from *Tamarix gallica mannifera*, believed by some to have been the source of the manna of the Israelits, while others attribute it to a lichen (*Lecanora esculenta*); American manna, from the sugar pine (*Pinus lambertiana*); California manna, believed to be deposited from *Phragmites communis;* etc. Some insects, as *Lavinus mellificus*, secrete a similar material. All of these saccharine substances are usually grouped together as false manna. They contain as their principal constituent melitose or melezitose, but no mannite. A large number of plants yield small quantities of mannite. For a discussion of their chemical composition, consult *Tollens Handbuch der Kohlenhydrates* (Breslau) 1895.

THE MANNA OF THE BIBLE

According to the biblical account, manna was the chief food of the Israelites during their 40 years' wandering in the desert (Ex. xvi.; Num. xi, 6-9). It is described as falling from heaven like rain or with the dew; small, round and white, like coriander seed; in taste, sweet like honey, or like fresh oil. It was gathered in the morning and it melted when the sun rose. A sufficient amount was provided daily for each individual and no more; if a surplus was gathered, it spoiled before the succeeding morning. On the sixth day, however, a double portion was provided, and none could be found on the Sabbath. It could be ground in a mill, beaten in a mortar, baked and made into cakes, or boiled. A command was given to preserve an omer of it in the ark of the covenant for future generations. (Cf. Heb. ix, 4). The supply ceased on entrance into the promised land. (Josh. v, 12.) In Ex. xvi, 15 the name is explained by a reference to the exclamation of the Hebrews when they first saw the manna and knew not as yet what it was, *man* being made equivalent to *mah*, "what is it?" This explanation is probably a species of popular etymology and indicates that the true origin of the word was unknown. In the later literature manna is called "corn" or "bread of heaven" and "angel's food." (Ps. lxxviii., 24-25, cv. 40; of John vi, 31; 1 Cor. x, 3.) Attempts have been made to explain the biblical manna as the exudation from the tarfa tree, a species of tamarisk (*Tamariz gallica mannifera*), or the camel's thorn, or as lichens. Manifestly such an explanation fails to satisfy all the conditions of the narrative. It is believed, however, that the latter represents an early tradition with later embellishments, the view becomes plausible that the use of some such food by a small tribe or clan in time of need may have formed the basis of the narrative. The passage in Numbers is attributed to the Yahwistic writer, and hence to preëxilix; that in Exodus is found in the priestly narrative, but it probably embodies certain old fragments with considerable additions by the redactors. Consult the commentaries of Dillmann, Baentsch, and Strack on Exodus xvi.

SAVE THE DOGWOOD!

IF popularity may be judged by the frequency of picking, the flowering dogwood may be said to be one of our most popular wild shrubs. From the time it begins to bloom in the spring, until the last flower has dropped, there is a continual procession, both afoot and in the automobiles to its haunts in the woods. The white spread of blossoms, as seen from the roadside, acts as a challenge to the passerby to enter and pick. Boys daily come trooping back to town with their arms full to dropping; automobiles return from their afternoon's ride in the country, their wind shields covered with the snowy white blossoms. A successful day! But let us ask ourselves if it was success? Rather, was it not thoughtless vandalism? The continual breaking of the branches and the cutting down of the whole of the smaller trees, is diminishing our dogwood to such a degree that there is danger of our losing these shrubs in localities accessible to towns, villages and cities.—Inez M. Haring in *American Forestry*, April, 1921.

Radioactivity and Soil Fertility

Some Important Researches by Professor Gabriel Petit, of Alfort, France

THE study of the remarkable phenomena of radioactivity has so profoundly modified our theories in every department of scientific thought as well as our practice in many branches of applied science that it is not strange that many investigators should have sought to discover whether this strange property of certain kinds of matter may not be utilized to advance that most ancient and vital branch of human endeavor, the science and art of agriculture. In 1913 the French Academy of Sciences testified to the importance of the subject by appropriating from the "Bonaparte Fund" several allotment subsidies of 2,000 fr. for the study of the influence of radioactivity upon the development of plants in general, and particularly upon *"the mutation, the reproduction, and the variation of certain species of plants."*

One of the most prominent and successful among the French investigators along this line is Prof. Gabriel Petit of Alfort, a member of the French Academy of Medicine, but known as an enthusiast on botanical research. This authority does not hesitate to declare, as the result of several years of research that properly employed "radioactive energies" can be of very great value indeed in this domain. Professor Petit has contributed to *La Nature* (Paris), for October 16, 1920, an account of his more recent experiments in this field, of which we present the following résumé. As we know radioactive bodies emit three kinds of rays: 1. The *alpha* rays, which are positively electrified atoms of helium; 2. The *beta* rays, which are likewise corpuscular but which are negatively charged; 3. The *gamma* rays, which are immaterially vibratory and comparable to the X-rays from which they differ, however, by their penetrability, since some of them, sufficiently tenuous to pass through the interval of space between the atoms—there is no other explanation—succeed in traversing sheets of lead from 20 to 30 cm. in thickness. This is the so-called *"ultra penetrant" radiation* filtered by means of a rigidly exact technique which is employed particularly and with great efficacy in the treatment of cancer by means of Radium-therapy or Mesothorium-therapy.

Since radioactivity, whose characteristic feature is in Professor Soddy's expression "a continual emission of energy" in the form of heat, electricity, and continuous vibratory and atomic projections, is it not reasonable to suppose that at low intensities it may exert a favorable influence upon vital phenomena, whether in men, in animals, or in plants?

Putting aside men and animals if we wish to give an immediate demonstration of the fact that radioactivity is capable of exerting a remarkable influence upon vegetation, we have but to choose among the most striking results of the experiments, still unpublished, which we have carried on at the School of Alfort with the skilful collaboration of M. Guillemain, the head gardener, a former pupil of the School of Horticulture at Versailles.

Let us take, for example, the tests conducted with potted plants after slipping. Two geraniums of the same age (variety Destinée) were grown side by side in pots, one being given the treatment while the other served as a control. Photographs of the pot show the former to be far more luxuriant, making the latter look sickly in comparison! But the two pots were exactly alike with respect to the earth which filled them, of which each contained 2.5 kg., the only difference was that in one of them 15 grams of a substance produced by the activity 0.11,[1] (*i.e.* with respect to the activity of uranium oxide which is taken as a unit) had been placed in the pot and intimately mixed with the earth at the beginning of the experiment on the seventh day of the previous May. The results obtained were photographed at the end of the three months.

Thus we see that this marked result of improved growth was produced by the infinitesimal proportions of 0.60 gr. per 100 gr. of earth, of the radioactive stimulant, since all of the surrounding conditions as well as the later treatment (open air, illumination, temperature, watering, etc.) were precisely identical for the two plants.

A second experiment of the same kind, but conducted on a larger scale, since it included 40 chrysanthemum plants, would seem even more interesting with respect to the peculiar radiosensitiveness[2] of the plant selected and to the importance of the dose. These 40 pots comprised: (1) 10 control pots; (2) 10 pots containing a total amount of 200 gr. of the same substance as before, having an activity of 0.11 (the proportion being 8 per cent); (3) 10 pots containing 300 gr. (the proportion being 12 per cent); (4) 10 pots containing 400 gr. (the proportion being 16 per cent). The experiment was begun June 16 and the plants were photographed August 2, before blooming. Photographs of a single plant chosen at random from each of the four lots and placed in order with the control plant first, exhibited a marked and steady progress in height and luxuriance of growth from the first to the last.

But we have not yet determined the amount of the toxic or fatal dose for each plant studied, though this information would be extremely interesting; such a dose, however, would probably be very large.

It is worth noting, however, that we exceeded without any inconvenience, on the contrary, the proportion of 10 per cent of the complementary radioactive excitant of the fertilizer, which was recommended to agriculturists.

We might multiply these examples indefinitely[3] and might speak likewise of the seeds sown in pots (oats, clover, lupine, vetch, etc.), which as a general thing produced equally satisfactory results—or we might mention our experiments in plant cultivation upon a large scale, *i.e.*, in the open ground, which concern beans, cabbages, leeks, etc., and are not yet completed.

If we admit that low degrees of radioactivity exert a favorable effect upon the growth of plants—a fact which it would be difficult to deny, in our opinion, in the light of the foregoing observations—how shall we explain it while awaiting the results of more extended and more rigorous experimentation? The problem is, indeed, both subtle and complex and fairly bristles with unknown points. But is this a reason for avoiding its consideration? Is it not true on the contrary that the deeper the enigma the greater its fascination for us? Let us reflect that the development of a mere seed planted in the ground holds our interest—that this soil is composed of a mixture which is essentially variable in character of organic and of mineral substances, some of which are present naturally, while some have been added in the form of fertilizers—let us remember, finally, that this soil contains a prodigious number of micro-organisms of all sorts without whose presence all life would be extinguished and some of which are useful while others are injurious.

Then let us put to ourselves the question as to what manner of effect radioactivity applied in the optimum dose will exert either directly or indirectly, first, *upon the plant* to stimulate it and increase its vigor; second, *upon the earth* to produce possible favorable modifications of its character so as to adapt it the better to the requirements of assimilation[4];

[1]Due to the kindness of the Société Française d'Energie et de Radio-Chimie.

[2]Already demonstrated in 1913 by M. Viand-Bruyant, the distinguished Poitiers horticulturist in experiments which he kindly undertook at our instance.

[3]Our experiments upon the brilliant sage, fuchsias, and anthemis gave the same perfect results.

[4]Prof. Daniel Berthelot, member of the Institute, Director of the Station of Plant Physics at Mendon, who was the first observer to note the withering of vegetation through radioactivity, has shown that a feeble electric current activates the decomposition of organic matter and thus renders it more assimilable.

and finally, *upon the microbes* themselves to augment or decrease their vitality as the case may be.

THE DIRECT ACTION OF RADIATION

As yet we hardly know which radiations are most effective in their action upon plants. Does this superior effectiveness belong to the *alpha* rays which are intercepted by the most fragile obstacle, but which are none the less electrified atoms, or to the *beta* rays and the *gamma* rays, which are more penetrating although they are divided into "soft" rays and "hard" rays? Since as yet we do not know how to dissociate their values[5] let us consider, while awaiting fuller information, the total radiation.

It is evident that the plant may be killed if too large a dose of the radioactive treatment be given, whereas, if a moderate and suitable dose be applied it will be, on the contrary, stimulative.

My late collaborator and friend, Dr. Henri Dominici, whose name will always remain associated with the employment of ultra-penetrant radiation in the treatment of cancer, proved by microscopic research upon animals that certain rays given off by radium are capable of occasioning through the integument either the necrosis of the conjunctive, dermic, and hyperdermic cells, *i.e.*, their instant death, or else their vigorous proliferation—the difference of effect being merely a question of the amount of the dose. How much more then would this hold true in the case of the amount of our young, sensitive, delicate plant cells, which are, moreover, more directly exposed since they belong either to the roots or to the embryo of the seeds.

EXPERIMENTS IN GERMINATION

M. Mattout, a collaborator of Professor Becquerel at the Museum of Natural History, readily succeeded in sterilizing the seeds of cress and of mustard by strong irradiations which proved fatal. In the same way M. Guilleminot operating with other seeds observed possibly for the first time under these conditions the accelerating action of low degrees of activities. Dr. Nogier,[6] associate professor of the Faculty of Medicine of Lyons, who is well known through his important works upon radium therapy, has made experiments with the seeds of annual plants, such as the balsam, larkspur, poppy, and clarkia, placed in boxes of thin cardboard to intense radiation from an apparatus containing assembled salts probably similar to those employed in dermatology. Naturally, in the formidable and destructive doses of 6,240 and 3,570 or 600 milligram-minutes.[7] He could not fail instantly to destroy the germinating power of most of these seeds. However, a few among them (Clarkias) which doubtless lay at the bottom or in the angles of the box and were thus comparatively protected and subjected only to considerably attenuated irradiations, were not only not killed, but after making a rather reluctant start they greatly exceeded in vigor of growth the control plant which had not been irradiated. This forms a demonstration—still quite imperfect, to be sure, but nevertheless convincing, of the exciting power, as the author expresses it of feeble doses of radium.

Together with M. R. Ancelin, an agricultural engineer, we ourselves previously to Dr. Nogier established the fact in a note prepared for the Acadamy of Sciences[8] of the favorable influence exerted by direct radioactivity upon germination. By allowing a specimen of water radioactivated to a known degree in comparison with ordinary water to operate upon various seeds (wheat, maize, barley, ray-grass), we were able to observe not once merely but *constantly* in all the lots treated that the rootlets and the stemlets proceeding from the embryos thus irradiated were incomparably larger and stronger! How shall we explain this impressive result if not by the increased intensity of the cellular multiplication under the durable and permanent action of feeble iradiation?

As soon as the contact is established—a contact let us remark which is increasingly intimate in proportion as the roots extend into a previously prepared soil—between a radioactive substance emitting electrified rays and the plant which receives the disturbance and shock due to these, it becomes *a priori* impossible that the plant should not be influenced either for good or for ill by this irradiation! In our opinion the results which we have just cited largely suffice to prove this direct action—injurious when it damages the cell but advantageous when it merely excites them.

EFFECT OF RADIOACTIVITY UPON THE MICROBES OF THE SOIL

As far back as 1912 we made an attempt to explain to the section of plant pathology of the First International Congress of Comparative Pathology, held by the Paris Faculty of Medicine,[9] the probable effect of radioactivity upon the fixation of atmospheric nitrogen and upon nitrification, which are, as we know, the grandiose work of infinitely minute organisms. This idea which seems to us a fertile one and which we believe we ourselves were the first to announce, has made headway since. . . . It should be stated that a note by M. Stoklasa, the director of the Agronomic Station at Prague, was read before the Academy of Sciences a year later, in 1913, giving a description of the experimental study of this theory. The substance of it may be stated as follows:

The well-known ionizing action of radioactive bodies and the moderate ozonization which results therefrom, favor pullulation and the functioning of the nitrifying microbes, which are aerobic in nature. Everywhere in fact where the force of radioactivity is exerted, the milieu is rendered a conductor.

The precise measurements made by the electroscope . . . of slight as well as of strong degrees of activity is justly based upon this phenomenon of ionization, which is always accompanied by the formation of a certain amount of ozone.

But ozone, whose oxidizing power is well known, is in fine merely the oxygen placed at the disposal of the nitrifying or fixating bacteria of atmospheric nitrogen.

The experiments of Stoklasa, which are worth quoting but need to be repeated with a stricter technique, prove that radioactivity acts upon these aerobic microbes in an advantageous manner, as affirmed by ourselves previously. Not only do they profit by the oxygenation of the milieu but perhaps they are likewise capable—why not formulate the hypothesis of utilizing, in their own vital processes and the hypher-functioning a portion of the liberated energy which has been put at their disposal.

However this may be Stoklasa[10] has studied by means of an ingenious technique the influence of radioactivity:

a. Upon the bacteria which fixate nitrogen;

b. Upon the bacteria which transform organic nitrogen leading to ammonia as a final product;

c. Upon the denitrifying bacteria which are in general anaerobic.

Without going further into these researches some of which are made with a rather impure radioactive mineral called nasturan or pitch blend[11] and sometimes, which is much better with the gaseous emanation of radium, we may state that they have enabled us to prove the formation in cultures thus treated and carefully analyzed of a very much larger proportion of nitrogen. In the same way the earth planted with nitro-bacteria is enriched with nitrogen when subjected to radioactive emination.

In our opinion the ozonization provoked by all radioactivity (*i.e.*, the flow of electrified particles of matter) is equivalent

[5]It is to be noted that the energy of the β rays is only about 1/100 that of the α rays.

[6]The Nogier *Lyon Médical*, Dec. 7, 1913.

[7]The quantity of emanation produced in 1 mm. by 1 ml. of radium bromide.

[8]*Acad. d. Sc.*, March 17, 1913 (Note presented by Professor Chauveau.

[9]Vide the volumes of Congré (Pub. by Masson).

[10]C. R. Acad. d. Sc., Nov. 10, 1913 (Presented by Professor Maquenne).

[11]Joachims, that pitch blend has an activity of 3.64 compared to that of uranium taken as a unit.

to a sort of permanent and homogeneous aeration of the soil which no other process is capable of accomplishing. Let us remember that certain bacteria whose presence is, indeed, of capital importance—since no plant will develop in earth previously sterilized—are not the only ones to benefit by this treatment. Without speaking further of the territory itself which serves them as a culture medium and within which there take place so many mysterious reactions and oxidations, which may thus be accelerated, there is only one sort of cellular physiology, and oxygen is indispensable to the creation of protoplasms, whether it belong to a man or to a blade of grass! The blood carries to our cells the vivifying oxygen which we breathe, but the plant must be surrounded by it or else it dies. The seed, in particular, which is about to germinate in obscurity encloses a living organism of exquisite delicacy, the embryo. From its differentiation there results first the fragile seedling and then the robust plant into which it splendidly expands. Oxygen supports and exalts the vitality of the embryo as well as that of the roots and the entire plant.

CONCLUSIONS

To sum the matter up the triple radiation (α, β, γ) with the production of electricity and of heat always exhibited by radioactivity are capable of being of essential service to vegetation. Moderate-powered irradiations produce a sort of harmless traumatism by means of their gentle but continuous bombardment, and thus undoubtedly exert a direct stimulus upon the plant cells in their path; the phenomena of heat and of electricity in their turn produce profound modifications in the milieu, rendering it more propitious to life, by precipitating the dissociation of organic matters destined to be assimilated; finally, the process of oxygenation is superadded, so to say, with the result of intensifying the vegetative functions while the pullulation of the countless germs present in the ever fecund earth occasion the fixation of atmospheric nitrogen on the one hand and nitrification on the other.

In short it is quite certain that radioactivity is capable of assisting plant life in very great measure. . . . But if it is too feeble it is inoperative, whereas if it is too powerful it is harmful. And herein lies the difficulty.

If we might advise agriculturists we would insist on their making a very careful previous study of those radioactive substances which contain no fertilizing principle within themselves, but which should be added to ordinary fertilizers that the plant may be stimulated as well as nourished.

It is evident that a vast field for experiment is here opened. It has been justly said that the rational application of scientific method ought both to facilitate the cultivation of the soil and to render it more productive.

Excretion in Plants*

Flowers, Leaves, Fruit and Bark Regarded as Excretory Organs

By P. C. Van der Wolk

JUST as animals do, plants secrete poisonous products of metabolism which must be rendered harmless. But while the animal excretes these substances and removes himself from their neighborhood, plants suffer the disadvantage of not being gifted with powers of locomotion. It has long been known in agriculture that because of this it is quite possible for plants to perish or to make the ground nonfertile. The appearance of unfruitful zones surrounding plants and trees; the impossibility which exists of plants living too closely side by side; the problem of what is known as "soil fatigue"; the hostility exhibited by certain plants toward given fertilizers; much of the reproach unreasonably ascribed to the physical condition of the ground; the entire question of the rotation of crops—all of these may be regarded as results of the phenomena of excretion in plants, to which too little attention has thus far been devoted, and which will eventually undoubtedly be regarded as lying at the very basis of modern agricultural science. An example indicating what an important rôle may be played by the problem of excretion in the most ordinary operations of gardening and field cultivation, is the observation that the pruning of plants improperly or at the wrong time tends in some inexplicable manner to deprive the ground in which they are grown of its fertility. As a matter of fact, we are here concerned with an actual poisoning of the ground through excretory matters which are forced to make their exit from the plants, through the roots, because the aerial organs of excretion, whose function it is to make the excreted substances harmless, or to get rid of them by evaporating them in the form of gases, *i.e.*, leaves and flowers, fruit and bark, have been ruthlessly cut away: This is the excretion theory of the effect of pruning!

Because of the fact that plants are unable to change their environments at will, the technological questions concerned with their excretion products differ from those concerning the excreta of animals, and on this account a very important feature of the matter is the circumstance that plants are in the habit of transforming many of the injurious products of metabolism secreted by them into gases, which pass into the air and are blown away. Among the gases thus liberated we must include not only carbon dioxide but all those fragrant substances which many flowers and leaves pour forth into the air.

The excretions of plants must be divided into those which are *direct* and those which are *indirect*, the former include those which are directly excluded from the organism, and this is the commonest form of excretion. But plants are also capable of changing products which are originally injurious into other substances which are quite harmless, and even of employing these for constructive purposes. This transformation of a harmful product to a harmless one is an example of *indirect excretion*. We find such products most beautifully exemplified in the *bark*, which in very many cases forms a thick cork-like layer of dead cells around the living body of the plant; this dead layer is continually thrust outward because of the fact that fresh products of metabolism must be rendered innocuous and yet, at the same time, this excreted substance plays an important part as regards the welfare of the plant.

It happens in a great number of cases, too, that the bark still contains toxic substances. The bark of a tree may be compared in general to that coat of armor formed by *chitin*, which encases insects since chitin likewise has its origin in the transformation of products of metabolism.

Excretions in Fruits.—An important instance of this sort of indirect excretion is furnished in fruits. The fruit of a plant consists essentially of a sort of storehouse of excretory substances, and it is a well-known fact that it is the fruit especially which constitutes the poisonous organs in a great number of plants, as, for example, the berries of many plants. These poisons include also the acids and tannins which make many fruits unpleasant to the taste. But when in the course of historic evolution this organ of excretion has become united with the organ of reproduction and thus contains the seeds of the plant it often occurs that by means of secondary enzymatic processes a portion of such excreted substances in

*Translated for the *Scientific American Monthly* from *Die Umschau* (Frankfurt), Jan. 29, 1921.

the fruit are transformed into products which are not only harmless, but may be even useful as nutritious substances, such as various kinds of sugars, fats, and albumins. In practical life we are accustomed to designate this sort of transformation as a *process of ripening.* The substances thus produced often serve as a store of nutrition for the use of the embryo and are of service later to the young plant during its germination. But we must not lose sight of the fact—indeed we may especially emphasize the possibility that this formation of sugar is an entirely independent process, whose original purpose was to render harmless the toxic excretion products. It was not until later that the organ of reproduction, *the germ of the future plant* became, united with the fruit, whether by chance or whether *because of the fact* that it found one sort or another of sugar ready for its use.

It is obvious enough that plants which are tied down to a definite location must exercise great care with respect to the getting rid of those excretory substances which they must reject, but which they cannot move away from. At the same time we must remember that this is the very reason why we are commonly unaware that the plant does reject excreted substances. The plant collects its excretion products in its own reservoirs and keeps them there until its period of rest occurs, at which time it gets rid of them. This can be recognized as *true not only in the case of the fruit but also in that of the leaves.*

The Fall of the Leaf.—Throughout the entire year and, especially, as autumn comes on, the leaves saturate themselves with substances which we know to be injurious to the life of the plant, and when these leafy reservoirs are filled to the brim the leaf flutters to the ground. The fall of the leaves at the end of the period of vegetation is primarily, indeed, a phenomenon of excretion. In short, *leaves are organs of excretion of prime importance.* And they accomplish their function, not only through transpiration but also by exuding drops of liquid by day, as may be observed in several house plants as well as at the points of blades of grass and along the rims of the leaves of the capucines. These drops contain a solution of various substances undesirable to the plant and sometimes in such great measure that they actually form a crust about the body of the plant. It often happens that excretory products collect in certain cells and are then decomposed by means of a secondary enzymatic process into delightfully fragrant oils, such as those of the orange and the lemon. The same thing holds true for flowers, since essentially speaking flowers and foliage are practically the same. We are willing enough to admit that the flower represents an "*adaptation*" for the purpose of attracting insects, yet it has, nevertheless, retained its essential character, which is the same as that of the leaf, *i.e.*, it is an organ of excretion; it becomes saturated with excretion products which are often cast upon the air in the form of perfumes, and it likewise falls to the ground when its appointed time has come.

With respect to the fact that flower petals are lacking in the function of nutrition because of the absence of chlorophyl, it may be remarked that the flower has developed more markedly than the foliage into a specific organ of excretion. That the flower so quickly loses its hold, as if the plant were glad to get rid of it as soon as possible has, therefore, an excretory significance. And to carry out this sort of "biological process of thinking" we may even regard the allurement of insects and their carrying away of honey and pollen, as being primarily of use to the plant as a means of getting rid of its excretion products, via the maw of the animal. Indeed it is quite possible that it is exactly on this account the plant has arrived, in the course of its history, at the location of its organ of reproduction in the flower, just as we have remarked with respect to the fruit. In this organ, too, it may be assumed that in *the beginning* this attraction of animals was meant to secure a carrying away from its own neighborhood of the harmful products excreted by the plant.

A NEW OIL PLANT FROM THE CONGO

By J. Pieraerts

The curator of the Museum of the Belgian Congo has recently announced his study of the seeds of a new oil bearing plant, which promises to be very valuable since the kernels contain over 47 per cent of fatty matters, yielding an oil which much resembles olive oil, being odorless, pleasant of taste, and non-siccative and producing with soda a very attractive light colored soap. According to M. Pieraerts (*Bull. d. Sci. pharm.*, Oct., 1920). The plant which bears this seed is an immense vine or liana of great strength, but at the same time very ornamental because of its rich foliage and large flowers. A marked feature of its growth is the production of an enormous tubercle, weighing from 10 kg. to 40 kg. This tubercle is very rich in starch, but it is reputed to be poisonous.

Further experiments will be made to determine whether the oli and the oil cake are likewise poisonous, and if this is the case, whether the toxic quality can be removed, which is done in many other instances as in the case of the manioc root from which tapioca is prepared. It is to be hoped that this can be done since besides the high percentage of oil the residual cake contains more than 19 per cent of nitrogenous substances. In any case, however, the oil will undoubtedly prove valuable for various industrial purposes.

THE PSEUDO-MIRACLE OF BLOODY SWEAT

The red colored perspiration, vulgarly known as "bloody sweat" is so striking a phenomenon that it was not unnaturally regarded in the Middle Ages as being of miracular origin. It sometimes makes its appearance on the skin of individuals suffering from over-fatigue or strong excitement and this would lend color, of course, to belief that the red color was really due to blood oozing through the skin. It was not until the existence of micro-organisms was demonstrated that science was able to discover the real explanation of this curious phenomenon. It is due, as a matter of fact, to certain minute living organisms which attack the human body and form thriving colonies in areas where there is much perspiration given off. These colonies are held together by a sort of mucus and since they are red in color this mucus has the appearance of drops of blood. This affliction is not specially injurious and can easily be remedied by washing the parts affected with soap and water and then applying a reliable germicide.

A close relative of this perspiration bacillus is responsible for the red dots which sometimes make their appearance on foodstuffs, such as bread, eggs, and milk, and gradually extend their area until the material is stained with "bloody" spots and stripes. It was the German naturalist, Herenberg, who first discovered that these spots of "blood" did not have their origin in a miracle, as was supposed by the credulous, but in a small organism called by him "the miracle monad" (*Monas prodigioso*).

In the Middle Ages this strange and peculiar phenomenon was thought to be the work of witches and other persons who had sold their souls to the devil, and many a poor wretch was persecuted as a supposed perpetrator of this defilement of food.

This sort of "blood" is sometimes found in ponds or on the ground, and this accounts for the so-called "bloody" rain sometimes seen, which was formerly thought to be a monstrous portent of coming evil. We now know that bacteria are responsible for all these strange occurrences. Millions of these minute organisms are occupied in the decomposition of the débris of plants and animals in water and on damp soil. Some of these are white, green, or yellow in color and, therefore, make but little impression on the eye even when present in large masses; but when they happen to be pale or dark red or brownish in color, they at once suggest to the eye of the ignorant an evil omen.—Translated for the *Scientific American Monthly* from *Ueber Land und Meer* (Berlin).

Laying the Dust with Fog

The "Nebulizer"—A Device for Artificially Producing Mist

By Donovan McClure

THERE is considerable difficulty in producing a satisfactory artificial mist, since most of the devices employed to reduce water to a state of fine division, merely produce a fine rain which soon falls to the ground. The problem is one of considerable practical importance; not only do scientists employ such fogs in the study of various problems but one of the most recent hygienic measures recommended for use in the so-called dusty trades consists in the formation of such a mist in which the particles of water gather to themselves the floating dust in the air. By taking the proper measures this mist can then be precipitated carrying down with it the foreign matter which is so injurious to the lungs of the workmen. It is well known that the rate of tuberculosis is very high among bakers, millers, workmen in textile factories, and other operatives engaged in trades where the atmosphere is filled with fine particles of suspended matter. Some recent experiments by an Italian physician, Dr. L. V. Nicolai, a professor at the University of Pavia, have led to the hope that this means of purifying the air without creating draughts and without merely blowing the dust from one area to another may be generally employed. Dr. Nicolai calls his process "nebulization" and it consists in the production of artificial fogs and their application to various hygienic, medical and industrial purposes.

Dr. Nicolai is a specialist in diseases of the ear, nose, and throat, and has, therefore, been attracted by the problem of causing curative agents to penetrate as far as possible into the respiratory passages. Being dissatisfied with the various atomizers of liquids already on the market, he set himself to the task of producing a better one, which he accomplished by using a Giffard injector in an inverse direction.

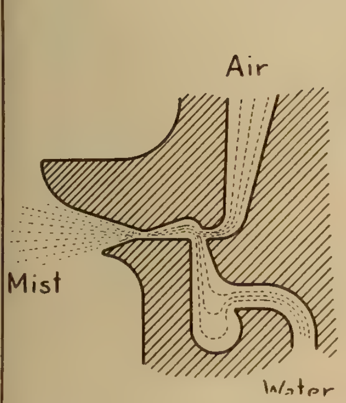


FIG. 1. DIAGRAM ILLUSTRATING THE PROCESS OF NEBULIZATION

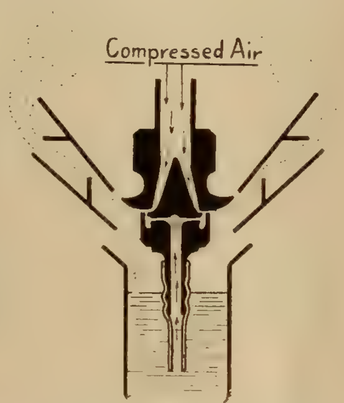


FIG. 2. OPERATIVE PRINCIPLE OF THE APPARATUS

Giffard injectors, Bunsen blow pipes and ordinary atomizers are based upon the principle of a fluid which draws along another fluid by means of the aspiration produced by the falling of liquids in capillary tubes. In some atomizers the two conducting tubes form an angle which may be as great as 90 deg. The sprays of droplets produced by such apparatus are always divergent along the cone of an angle which is more or less acute. As a result of this fact there is a great range of size among the drops which make their exit at the same time, since some of the drops run together to form larger ones. In fact the spray issuing from the ordinary atomizer is heterogeneous in nature and somewhat indefinite as to its character.

In Dr. Nicolai's device, on the contrary, the droplets are extremely tenuous and are produced without any complicated apparatus such as is required in those apparatus which make use of capillary tubes through which it is impossible to force liquids effectively except by means of strong pressure.

In the Nicolai instrument the liquids are drawn up by the barometric depression which is produced by the flowing of a current of air under 3 kilograms of pressure, and this flow is effected in a horizontal plane in a circular and radiating movement over as large a surface as possible. Furthermore, the space limiting the passage of the fluids can be regulated at will in order to obtain the best results.

The stratum of spray thus produced can be projected directly into the atmosphere if desired, but in this instrument a double walled bell jar in the form of a funnel is interposed. The selective effect thus produced is increased by the use of staggered baffles upon which the larger particles of fluid strike and break.

By this means a very fine mist-like spray is ejected from the ring-shaped orifice at the top of the apparatus. The intensity of this artificial mist is proportionate to the yield and its degree of opacity depends upon the density of the liquid employed.

Various investigators have produced artificial fogs for purposes of study, Salies de Béarn, among others, and have found that with saline solutions registering 5 deg. B. the fog produced soon becomes sufficiently opaque to absorb the radiation of a 50-candlepower lamp at a distance of 1½ meters. The "nebulized" fog produced by Dr. Nicolai's apparatus consists of liquid particles of from 1 to 5 microns in diameter; it spreads in any atmosphere whatever, sharing in the eddies produced in the air either by variations of temperature or by the sweeping movement produced by the arrangement of the apparatus. It flows along the walls, rising and falling, and homogenizing the atmosphere and it takes several hours to settle. This nebulized fog carries electric charges of the same size which tend to repel each other and thus prevent condensation, which is a very important point as regards its persistence. Because of its extreme fineness it penetrates all the interstices of fabrics, furs, tapestries, etc., without making them damp. For this reason it serves admirably for producing humidity in dusty factories or work rooms. Furthermore it may be made the medium for bearing healing agents, such as balsam, saline, salts, etc., which it will distribute in a very homogeneous manner.

ARTIFICIAL FOG UNDER THE MICROSCOPE

When examined under the microscope this fog exhibits the form of a mass of spherical droplets, whose diameter indicates that they possess a very high superficial tension. These infinitesimal corpuscles are naturally so light in weight that the resistance offered them by the air almost overcomes the force of gravity. It is assumed that natural fogs require the presence of a nucleus of condensation as one of the conditions of their production. The nebulized saline solutions behave in the same manner as natural fogs, but when perfectly pure water is nebulized the fog produced is considerably less opaque. It is because of this greater degree of transparency that this process of nebulization can be used to purify auditoriums, laboratories, and work rooms without disturbing the atmosphere.

In studying fogs thus produced, Dr. Nicolai found that the opacity of the fog increases with the temperature and that by cooling the fog, it can be rendered transparent. Moreover he found that increasing or diminishing the pressure does not alter the structure of the fog, which when brought back to

ordinary atmospheric pressure perceptibly resumes its initial condition; the lowering of the temperature occasions a deposit of drops of dew on the walls which is in accordance with the theory.

Because of the extremely fine state of division of liquids thus secured the latter are able to penetrate all cavities as readily as the air which bears them, and this renders them applicable for giving medical treatment to the natural cavities of the body such as the respiratory passages, the auditory canal, etc. A very great advantage, too, is that this treatment can be given every individual in a room, which adapts it for use in wards of hospitals as well as for private patients. In the same way, too, school children can be subjected to such treatment during their hours of recess, or in study rooms, or in gymnasiums, receiving the healing fog without even realizing its presence.

There are certain mineral waters which are very beneficial in cases of catarrh, influenza, scrofula, etc., and these can be readily nebulized and applied in this form. Another advantage is that the apparatus may be so arranged as to yield a warm fog and, therefore, the healing compound can be supplied to the patient at the temperature of the body, which tends to suppress irritation, facilitate secretion, and reduce œdemas.

A desirable feature of the apparatus is the possibility of attaining any degree of humidity desired without injuring the respiratory organs of persons who are obliged to stay in rooms where humidity is necessary, such for example as the textile industry.

DISINFECTION

Disinfection tests made by the inventor prove that all pathogenic germ not only in the atmosphere but in fabrics and furs, books and papers, etc., can be completely sterilized in five to twelve hours, even where there are several thicknesses of cloth or paper. It was even found that mattresses and pillows badly soiled by infectious discharges, could be thoroughly disinfected provided a comparative vacuum was produced before the beginning of the nebulization process. This finding makes obvious the value of the process in hospitals, since even bandages and instruments can be completely sterilized by its use.

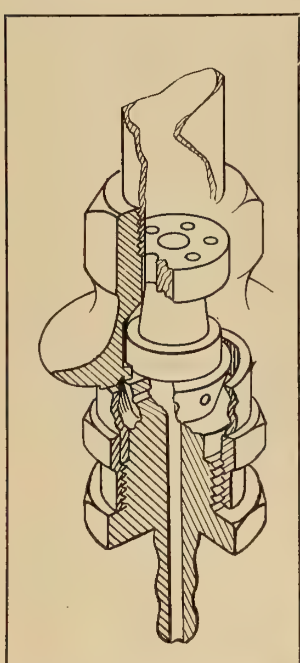


FIG. 3. CONSTRUCTIONAL DETAILS OF THE NEBULIZER

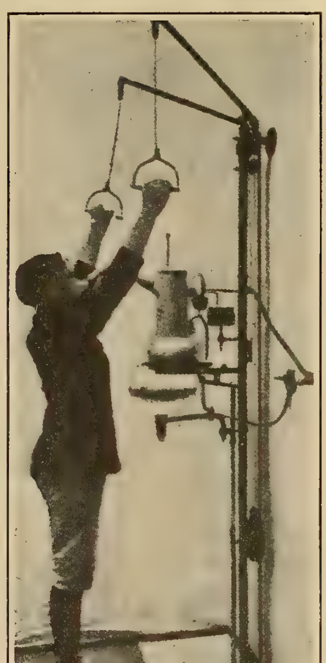


FIG. 4. NEBULIZER USED FOR INDIVIDUAL INHALATION

A definite degree of humidity is required in work rooms where the fibers of cotton or linen are spun or woven. Thanks to the nebulizer the atmosphere may be made humid enough to prevent the fraying of the fibers while at the same time it remains perfectly respirable.

A very interesting point brought out by Dr. Nicolaï is the conclusion to which he came that the nebulized fog probably behaves in the same manner as the high frequency currents with which some investigators have sought to obtain the same end. Not only the textile industries but those which manufacture powders and chemical products frequently require a definite degree of humidity for one reason or another—for manipulation, combination, or conservation, and in all these cases the new process is advisable.

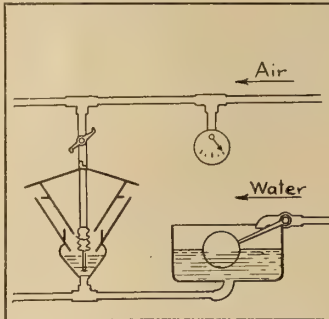


FIG. 5. USING THE NEBULIZER TO HUMIDIFY THE AIR

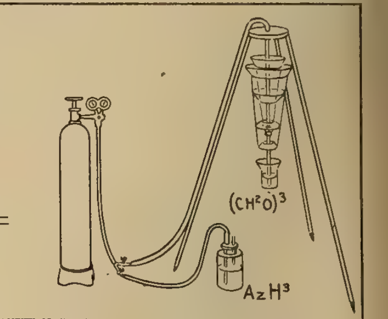


FIG. 6. THE NEBULIZER DISTRIBUTING DISINFECTANTS

We have already spoken of the production of medicated fogs for use in schools, hospitals, auditoriums, etc., where numbers of persons can be treated at the same time at comparatively small expense. It may be added that instead of this humidification of an entire room the healing fog may be produced by means of an inhaler at the entrance of the respiratory passages of an individual. A great many instances will suggest themselves where animals attacked by microbic or cryptogamic diseases can be successfully treated in this manner, as may also many plants suffering from diseases due to harmful fungi, etc.

Even the best carburetors used at present in explosion motors occasion a good deal of waste of fuel because of the imperfect mixtures they produce. It is claimed that this apparatus produces a much more intimate and therefore successful mixture of the combustible (under pressure) with the carburizer and, therefore, effects considerable saving. The apparatus can be so modified also as to perform the same service in oil burning engines. The inventor is already testing various forms of construction to discover the best form for nebulizing light oils, on the one hand, and heavy oils on the other. Another application is in the dairy industry where it can be used to produce a state of fine division in the fatty elements of milk, so that they may be the better held in a state of suspension.

SEALING GLASS WITH OPTICALLY FINISHED SURFACES

FOR the purpose of making pyrometer lamps with plane sides, a method of sealing a glass plate with optically finished surfaces to a tube was developed. The process consists essentially in heating the parts in a suitable furnace to a temperature determined by the annealing characteristics of the glasses to be joined, and then making the seal by applying a very small flame to the joint, the heating being localized so that the finished surfaces are not distorted except for a very small portion at the joint. The method has been applied to the making of various kinds of cells used in optical work and represents a distinct advance in the technique of the manufacture of such apparatus. A paper describing the method and showing some of the results obtained has been published in the *Journal of the Optical Society of America.*

FIG. 1. COTTON FIBER ENLARGED 160 DIAMETERS

Note the "twisted ribbon" appearance of the middle fiber

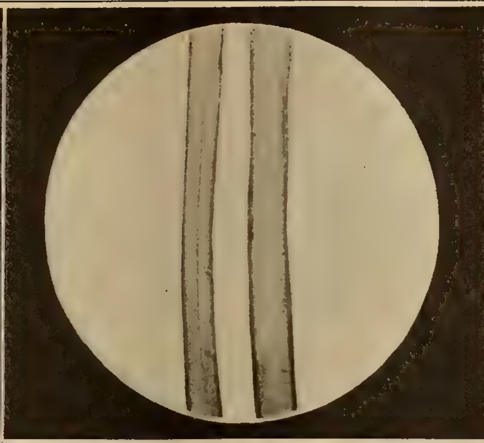


FIG. 2. MERCERIZED COTTON, X 160 DIAMETERS

Fibers untwisted under tension in a hot caustic soda solution

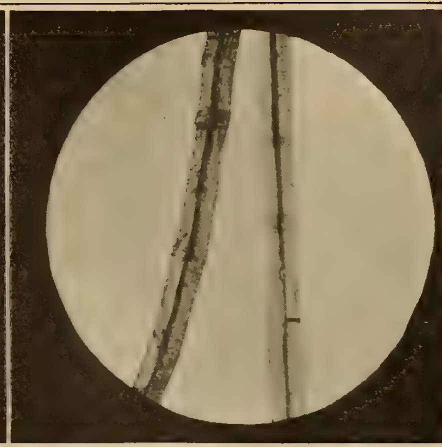


FIG. 3. FLAX FIBERS ENLARGED 120 DIAMETERS

Note the "bamboo-like" appearance due to the jointed structure

Textile Fibers*

Nature of the Fibers and Tests for Their Identification

By Harvey G. Elledge and Alice L. Wakefield

Industrial Fellows of the Mellon Institute of Industrial Research

THE records obtained by archeologists dating back as far as 2600 B. C. show the arts of spinning and weaving to have been in a late stage of development at that time. Beyond that date nothing definite is known because no records have been found; in fact, no records are expected of the very earliest stages since these arts appeared long before man began to express himself by means of writing.

However, from our present knowledge of man and the progress of his ideas and intellect from infancy to manhood, it has been possible to imagine the first steps taken by primitive man in the evolution of the art of cloth manufacture. When the first desire or need for body covering arose, our ancestors took what lay nearest at hand and clothed themselves with the robes which nature had furnished their less highly endowed brothers, the four-footed, fur-bearing animals. To do this, implements for obtaining the skins were necessary, and the cleverness displayed in their preparation soon found expression in another way. Rushes and fibrous grasses were plaited or woven into mats that were found to be much lighter and more suitable for purposes of clothing in certain climates and seasons than were the animal skins.

Continued use of the grasses demonstrated that an exceedingly wide field of application of heretofore useless materials had been opened to ingenious minds. Experience proved that for purposes of covering or decorating the body some plants were more desirable than others. The desirable features of these plants were found to be confined to one section of the stalk, the section lying between the bark and the woody portion; these features were toughness, pliability and greater ease of bleaching. Primitive man was even more prone to personal decoration than civilized man and early realized that white cloth gave him clearer and more brilliant colors than gray or cream cloth did. The fibers that resulted from the manipulation of rushes and reeds by the ancients are the linen fibers of today; and by virtue of their descent from reed weaving, and the fact that reed weaving goes back beyond any other type of weaving, linen fibers may be called the oldest of the textile fibers.

Long after grass fibers were first used, but before their use had reached any great degree of perfection, the possession of herds had brought a knowledge of wool. Wool originally did duty as a body covering in the natural form of an unclipped skin, and the real value of wool fibers became apparent only after the discovery was made (by accident rather than by intent) that by simultaneously pulling and twisting the clipped wool a long continuous strand could be obtained. This process of pulling and twisting (later called spinning) was quickly applied to other fibers, and, by means of it, many fibers, hitherto useless for weaving, by reason of their extreme shortness, were added to the list of useful natural products. Cotton was the most important of these later additions, but, like silk, was not used extensively for a long period and was regarded as a rare luxury. Today, however, the relative economic values have changed so that cotton heads the list as the one fiber used most universally and in largest quantity, while linen, wool and silk take their places in the order named.

It is interesting to note that these four fibers, known now for ages, still remain the best and most useful aids to man's physical comfort. They are grouped as vegetable fibers (cotton and linen) and animal fibers (wool and silk), on account of the sources from which they are derived. The vegetable fibers are further differentiated as seed and bast fibers; *i.e.*, fibers from the seed pod and fibers from that portion of the stalk known as the bast region, lying between the outer bark and the inner woody portion.

COTTON

This fiber (which is useful only when ripe) belongs to the class of seed fibers and is disclosed in the ripe burst seed pod as numerous white hairs or fibers attached to the seeds. Before spinning, these fibers must be removed from the seed and, previous to the invention of the cotton gin by Eli Whitney, this was done by hand. Microscopic examination shows the individual fiber to be a long, slender, flat tube, spirally twisted about its axis. Fig. 1 is a photomicrograph (a photograph taken through a high power microscope) of cotton showing the details of its structure. One end will be found closed and pointed; this is the loose end of the fiber as it grew within

*Abstracted from "The Conservation of Textiles," by Harvey G. Elledge and Alice L. Wakefield, by permission of the publishers—The Laundryowners National Association.

[1]Fig. 1 is copied from the "Encyclopedia Britannica." Figs. 2, 5 and 6 from "A Manual of Dyeing," by Knecht, Rawson and Loewenthal; Figs. 3 and 4 from "A Manual of Modern Steam Laundry Work," by E. Clayton.

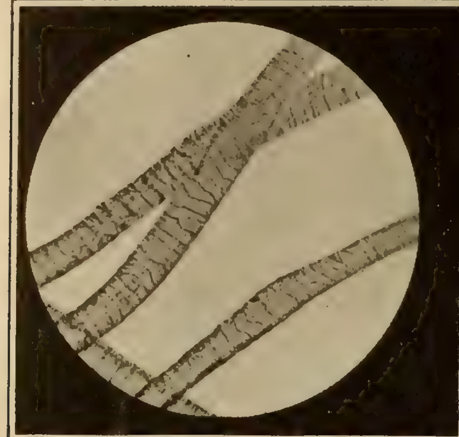


FIG. 4. WOOL FIBERS ENLARGED 120 DIAMETERS

Note the overlapping scales that characterize wool fiber

FIG. 5. "BOILED-OFF" SILK, X 100 DIAMETERS

The gum has been boiled off, revealing the glossy fibers themselves

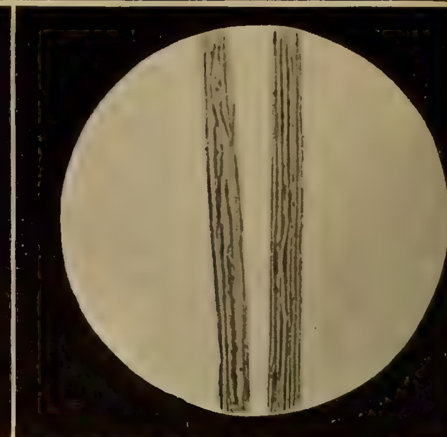


FIG. 6. RAW SILK ENLARGED 60 DIAMETERS

Each strand is really two fibers covered with a coating of gum

the seed pod. The other end will be found blunt and ragged where it has been torn from the seed. The fibers vary considerably both in length and width, the longer ones being best suited for spinning and weaving because when spun greater intertwining of the individual fibers occurs, resulting in a yarn of greater strength than that spun from shorter fibers. Actual measurements show the variation in length of the fibers to be, on the average, from eight-tenths of an inch to one and eight-tenths inches, although some fibers come as short as one-half inch. These extremely short fibers are usually combined with longer fibers to insure for the finished yarn a reasonable tensile strength. Such is not always the case, however, and many damages exhibited by fabrics are the direct result of the use of these short fibers alone, without the reinforcement of a percentage of longer fibers.

Mercerized Cotton.—A variation of the natural cotton is mercerized cotton. The difference between the two is physical rather than chemical, although it is brought about through the action of caustic soda. Mercerization causes the fiber to become transparent and to lose its flat spiral form to become a nearly straight cylinder having an increased power of light reflection and consequently a higher gloss. This change in form is illustrated by Fig. 2. The mercerized fiber is even stronger than the raw fiber when the conditions of mercerization have been carefully guarded and overtreatment avoided. The only part of the change that is apparent to the eye, unaided by a magnifying instrument, is the increased gloss.

Schreiner Finish for Cotton.—A high luster, similar to that appearing on mercerized cotton, can be given to a piece of cotton cloth by subjecting it to a process called calendering. This process consists of passing the cloth between rollers under heavy pressure. One of the rolls is engraved with obliquely set lines, ruled from 125 to 600 to the inch; these lines produce a great number of parallel, flat surfaces on the cloth, which cause it to acquire a high luster. If the rollers are heated during the process, a finish is produced that closely resembles mercerized cotton, and is quite permanent. This finish, however, is lost to a large degree on washing.

LINEN

Linen is a representative of the bast fibers and is obtained by fermentation of the whole flax plant. This process prepares those parts of the stalk that are undesirable as textile fibers so that further treatment by drying and rolling removes them, leaving the long tough fibers to be used for spinning. When examined microscopically (see Fig. 3), a linen fiber presents a more or less bamboo-like structure, caused by the occurrence of several cells in sequence, with nodes or knots at irregular intervals where two cells are joined at the ends. An individual cell measures in length from twenty to forty millimeters (7/100 to 15/100 of an inch); consequently the long fibers of combed flax linen consist of a large number of cells attached end to end. These fibers, by virtue of their greater length, furnish a much stronger yarn than does cotton.

WOOL

Wool and silk, though grouped together as animal fibers, are produced in entirely different ways. The term wool is usually taken to mean the hair of the sheep, although the hair of certain goats (Cashmere, Mohair, etc.) and of the camel are classed under the same name. The kind of animal from which it is obtained and the location on the body determine the quality characteristics of the wool, which may be short or long, coarse or fine, dull or lustrous. A long stapled wool fiber is one that measures over one and one-half inches in length, and its diameter is usually proportional to its length. Long stapled wool is generally combed and spun into worsted yarn and used for the best qualities of coatings, dress goods, etc., while the short fibers are carded and spun into woolen yarn, which is subjected to a fulling process subsequent to being woven into fabrics, in order to impart thicker and fuller feel to the fabric.

A close microscopical examination of wool reveals a cylindrical fiber covered with flattened, horny scales, which are funnel-like and which overlap each other in the manner of fish scales (see Fig. 4). The dimensions, uniformity and compactness of these scales are generally conceded to determine the luster and strength of the wool.

Wool differs from the vegetable fibers in several important respects. It possesses greater elasticity and strength and is more lustrous; it is curly and has the property of becoming felted under certain conditions, which are outlined in the L. N. A. charts of Standard Procedure for Washroom Practice as including the use of too low a bath with too little soap. This property, while being useful in certain ways, is a nuisance in others, and it is well for launderers to keep this fact in mind when handling woolen articles. The exact physical change that takes place during the process of felting is still under discussion, but experiments carried out by the Department of Chemical Engineering of the Laundryowners National Association have proved that it is the result of hard pounding in the wheel rather than of changes in temperature, which was first given as the cause of the phenomenon and was said to cause contraction of the fiber and an interlocking of the scales. The observation made by this Department upon the cause of felting is substantiated by the research findings of the United States Government workers on this problem.[2]

SILK

Silk is a substance secreted by several species of caterpillar

[2]A full report of the work is to be found in the laundry trade journals for the early part of 1919.

for the purpose of forming a cocoon in which the change from the caterpillar stage to the moth stage of existence occurs. It is produced by two glands, situated one on each side of the body, and is carried by ducts to the head of the caterpillar where the spinneret is located. Here on coming in contact with the air the two gelatinous streams solidify and are cemented together by another secretion which is produced by glands located near the spinneret. While all caterpillars spin cocoons in this manner, the secretions of only a few species form strands of sufficient strength to make them of value as textile fibers. When recovering these fibers for spinning, the cocoons are placed in water at a temperature of 60° C. to soften the cement which binds the two fibers together. When this softening has taken place the fibers are reeled on spools, several strands being reeled together to form a thread.

Raw silk (unreeled silk or the cocoon proper) is of a creamy or yellowish color and has very little luster. When examined under the microscope it appears as two straight, transparent fibers, absolutely lacking in cellular structure, cemented together along their whole length (Fig. 6). When boiled with soap solution, the outer layer of cement is removed, and the true luster of the fiber is revealed (Fig. 5). A silk fiber varies from 500 to 1,500 yards in length and in diameter from 0.01 to 0.02 millimeters (4/1000 to 8/1000 inch). Besides the advantage afforded by such exceptional length, silk is extremely elastic and is the strongest and most lustrous of the natural fibers. The best silk is produced by silk-worms reared under artificial environment and carefully cultivated, and is finer, whiter and more lustrous than the so-called "wild" silks obtained from the cocoons of uncultivated worms.

Artificial Silk.—The demand for silk has reached such proportions that efforts to supply its beauty at a popular price have led to the manufacture of artificial silks. The most important varieties of these fibers are prepared by the same fundamental formula, which calls for a solution of some chemical product of cellulose in an appropriate liquid. Of the two types of artificial silk on the market, the better known is made from cellulose hydrate, more commonly called viscose. The other type is manufactured from cellulose acetate, and sold under the trade-name of "Lustron." Viscose and cellulose acetate "silks" differ materially, chemically, but the physical differences are not marked. However, the identification of the type to which an artificial silk belongs may be readily accomplished in the laboratory.

The process of manufacture of artificial silk is briefly as follows: A solution of viscose (or of cellulose acetate) in a suitable solvent and of desired concentration is extruded by appropriate mechanical devices in such a way as to convert the viscous solution into filament form. These filaments or threads are placed into some medium that causes immediate coagulation or hardening, and are reeled from this coagulating material and prepared for weaving in the same manner as silk, *per se.* None of the varieties of cellulose silk possesses the strength and elasticity of real silk nor its resistance to the process of washing; they all have to be handled with considerable care and even with such treatment the results obtained are often not entirely satisfactory.

This product of the chemical laboratory can hardly be differentiated from real silk by microscopical examination because of the absolute lack of physical characteristics that exists in both types of fiber; it happens, however, that the one physical point of difference lies in the greater luster of the artificial silk, which shows such an increase over that of real silk that identification can be made merely from an inspection of the fabrics. In case any doubt remains in the mind of the inspector recourse may be had to simple chemical tests that are infallible.

TESTS FOR THE IDENTIFICATION OF FIBERS

Differentiation of Artificial and True Silk.—The simplest of these tests is burning and identifying the odor that results; an odor as of burning feathers indicates real silk, an odor as of burning wood indicates artificial silk. Another test, that improves on this test by replacing the factor of personal judgment with one of purely chemical character, is conducted by heating a portion of the fibers under examination in a dry test tube and testing the reaction of the volatile matter driven off by this treatment with a piece of moist neutral litmus paper placed at the mouth of the test tube. If the litmus paper becomes red, the fumes are acid and prove the fibers to be artificial silk; if the litmus paper becomes blue, the fumes are alkaline with ammonia and prove the fibers to be real silk.

These are two of the few reliable tests recommended for the identification of textile fibers. Textile literature is filled with tests that are said to be good and that have been praised beyond their actual merits. It is often quite possible that these tests deserve their reputation for great delicacy of indication, provided we consider one important factor, *i.e.*, the relation of the manipulator to the results. If the delicay of the test is greater than the degree of delicacy of technic that lies within the possibilities of the average manipulator, the chances are that the test will fail when applied by other than the man who has worked it out. The process of evolution has gained for the originator of the test a knowledge of

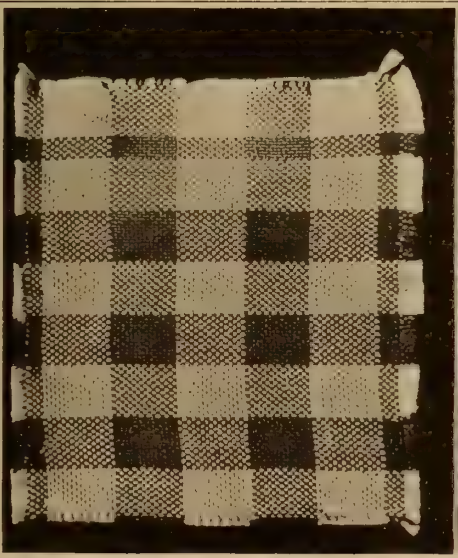


FIG. 7. A WOOL AND COTTON MIXTURE, THE WOOL DYED DARK

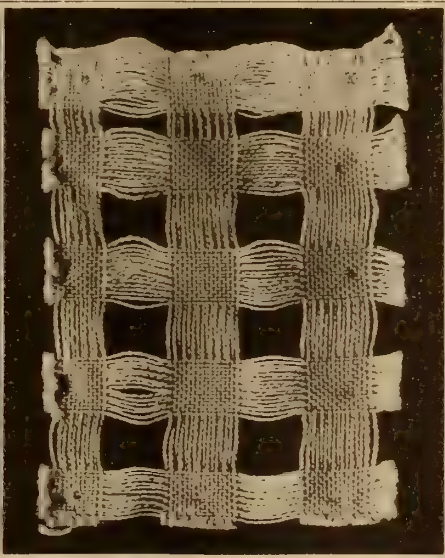


FIG. 8. COTTON THAT HAS SURVIVED TREATMENT WITH CAUSTIC SODA

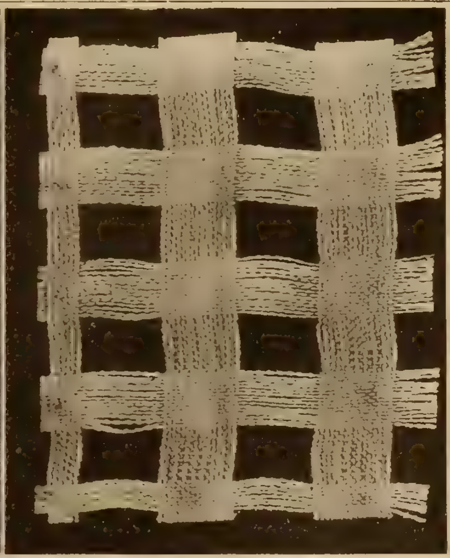


FIG. 9. WOOL THAT HAS SURVIVED TREATMENT WITH SULFURIC ACID

the reactions involved and a fineness of technic that is denied to others who may attempt to use it. It is deemed advisable to include in this chapter a discussion of the tests that have the full endorsement of the authors.

Tests for Vegetable Fibers in Mixtures.—If the presence of cotton or linen is suspected in a wool or silk fabric, proof can be obtained by boiling a small piece of the cloth in a 5 per cent solution of caustic soda for five minutes. At the end of this period the wool or silk will be entirely dissolved and any cotton or linen that may be present will remain unaffected by this treatment.

Tests for Animal Fibers.—If, on the other hand, it is desired to remove the cotton or linen and leave the wool or silk, the cloth may be saturated with a 2 per cent solution of sulphuric acid (H_2SO_4) and then dried in an oven at 100° C. for an hour. This treatment chars cotton and linen fibers and they can be readily removed by rubbing the cloth gently between the palms of the hands. The wool and silk successfully resist the action of the acid. These tests may be made quantitative by using weighed samples, carefully washing, drying and weighing the residue. The weight of the residue divided by the weight of the sample and multiplied by 100 equals the percentage of wool or silk in the case of treatment with sulphuric acid, and of cotton or linen in the case of treatment with caustic soda. Figs. 7, 8, and 9 illustrate the application of these treatments to a fabric of cotton and wool mixture. Fig. 7 shows a piece of the whole cloth that has been dyed with an acid dye and later bleached to differentiate between the cotton and the wool. The cotton is bleached white while the wool retains its color. Fig. 8 shows the cotton threads that have resisted the action of boiling caustic solution, the open spaces having been occupied by the wool that was dissolved out by this treatment. Fig. 9 shows the condition of the fabric after treatment with sulfuric acid, and presents the unaffected wool fibers with the cotton removed.

It is possible to differentiate between the two animal fibers by chemical analysis, but the procedure is too complex and the apparatus required too bulky to be at the command of everyone. There is no chemical means of differentiating between the vegetable fibers in spite of the oft-repeated statement that such differentiation may be made by treating a mixed cotton and linen cloth with concentrated sulfuric acid for one or two minutes, drying and washing. The statement is made that the linen will survive this treatment while the cotton will not. The degree of solubility of cotton in sulfuric acid approximates that of linen too closely to permit a separation by this method. For these reasons, in cases that prove difficult to decide, it is often desirable to conduct final tests with the microscope.

Although the examination of a fiber with the microscope is the quickest and most reliable method of identifying it, there are times when the microscope is inaccessible and when we must be prepared to recognize fibers from their characteristic appearance when spun and woven into fabrics. The characteristic appearance of the four fibers considered here, as observed without chemical or physical aids, are distinct, yet the best way to acquire a knowledge of their differences is to obtain pieces of material, pick them apart, feel them, and examine them closely for distinguishing features. There are certain statements which can be incorporated into such a book as this, like the fact that mercerized cotton is glossier than natural cotton, and that silk is glossier than either natural or mercerized cotton; that linen has a gloss, but that it is not so hard or high as that of silk or even mercerized cotton; that wool is crinkly and elastic, etc. But what we cannot do is to describe accurately the difference between the several glosses or between the crinkle due to the nature of the wool fiber and that which is acquired in the fabric as the result of the strain exerted by the crossed threads, so that the reader may judge all cases unerringly. There are things that the eye can perceive quickly and the mind retain readily, but which are difficult of description.

TEMPERATURE AND HUMIDITY IN STORAGE OF EGGS AND CANDY

By Owen T. Lay

Early in 1918 the writer was requested by the manager of one of the largest and most modern cold storage plants in Chicago to assist in an investigation of aqueous vapor in its relation to certain cold storage problems, especially in the storage of eggs.

In order to preserve eggs fresh successfully it is of course necessary for them to be so handled that the life germ (in those that are fertile) is kept dormant, this generally being accomplished by providing a uniform temperature slightly above their freezing point, which is near 28° but varies somewhat with the time of year when laid; and at the same time, keeping the air in the storage room pure, with just the right amount of well diffused water vapor. If the relative humidity is too low the interior moisture of the egg will escape, resulting in a loss in weight and a product that must be placed on the market at a loss as "shrunken"; while, on the other hand, if a high relative humidity obtains for any considerable period mold will form on the cases, fillers, and eggs and affect the flavor seriously.

Throughout the first season, closing in January, 1919, humidity inspections were made bi-weekly in eight rooms, containing approximately 20,000 cases each, it being found that in these heavily insulated rooms which were kept sealed almost constantly, the temperature could be held within 0.5° of the desired degree and the relative humidity held quite constant, although tending to increase gradually as the season advanced. To combat this increase varying quantities of unslaked lime were introduced and at times calcium chloride boxes were used in conjunction with electric fans. However, it was learned that the arbitrary standard of about 88 per cent for the relative humidity was too high, this percentage having been thought about right by many experienced cold storage men; hence, readjustment to a lower percentage was found advisable for the second season, which extended from May, 1919, to January, 1920.

During the second season 14 rooms in the same plant, containing about 250,000 cases, were inspected weekly. Through study of the data gathered during the preceding season, much more desirable results were secured; while, during the third season, closing with January, 1921, the work was expanded to include four storage houses, with about 600,000 cases of eggs and 10,000,000 pounds of candy. The candy included chocolate creams, chocolate nut bars, caramels, hard candies, etc., two ozone machines being used occasionally in keeping the air clean. Most kinds of candy keep best in a dry room, with moderate temperature.

Thanks to the zealous care of those in charge of the mechanical side of the cold storage houses, the practical experience of the superintendents and some of the temperature control men, who now have a basis of carefully compiled data for their own building, reports indicate that the season now closing has been remarkably successful, no complaints have been made, although some of the eggs have been held eight or more months and some of the candy for a year.

It has been found that sling psychrometer readings are the most practical method of finding the relative humidity in different portions of the rooms, a special cold storage instrument graduated to tenths of degrees being very convenient, as well as exact, if carefully used. However, this instrument is intended only for readings of 40° or lower and cannot be used in some candy storage rooms. Graphs are prepared for each room to show the progressive trend of temperature and humidity, temperature readings being taken every four to six hours. At the time the product goes out of storage the factors influencing its condition are plotted for comparison with the ideal sought.

The firm for which this line of work was undertaken is now reconstructing a large warehouse so that the factors of temperature, humidity, and air circulation may be absolutely controlled mechanically.—*Monthly Weather Review*, Dec., 1920.

Stainless Steel*

Non-Corrodible Properties of Steel Alloyed With Chromium

By J. H. G. Moneypenny

THE commercial utilization of the non-corrodible properties of steel containing about 12 per cent of chromium may be regarded as one of the outstanding events in the metallurgical world during the past decade. Steel, the most widely-used metal, unfortunately corrodes rather easily, and great precautions have to be taken to protect it, especially in exposed positions. This is particularly noticeable in such large engineering structures as the great railway bridges over the Forth and Tay, where painting is going on practically continuously. The production of a type of steel possessing great resistance to corrosion has obviously a great future, and one may safely say that, as yet, only the fringe of the possibilities has been touched.

Stainless[1] steel contains essentially 11 to 14 per cent of chromium and, for most purposes, not more than about 0.45 per cent of carbon. It frequently contains small amounts of nickel, say up to 1 per cent, but this element has no beneficial effect on the non-corrodible properties, while its presence, if unsuspected, may cause trouble in the heat treatment of the steel, since it has quite a considerable effect on the position of the critical ranges of the steel.

From a microscopic point of view, high-chromium steels, such as stainless, have a great deal of interest. Chromium has the effect of lowering the eutectoid composition in steel to a considerable extent. Whereas in ordinary steel about 0.9 per cent carbon is required to produce a structure consisting entirely of pearlite, with 12 per cent chromium, the same effect is produced with approximately 0.3 per cent carbon. Free carbide or cementite appears when the carbon exceeds this amount. In these steels, also, only part of the carbide forming the pearlite goes into solution at the lower critical temperature change on heating (Ac1), the rest dissolving progressively over a range of some 200°.

The state of combination of the sulphur in these steels requires further investigation. This element is only evolved to a very small extent as sulphuretted hydrogen on dissolving the steel in acids. The evolution method cannot be applied for its estimation, neither can one obtain an ordinary sulphur print on bromide paper. For example, a steel containing 0.07 per cent sulphur only gave a very faint print even after 15 minutes' contact with bromide paper soaked in 10 per cent hydrochloric acid or 15 per cent sulphuric acid. The print obtained was different in type from an ordinary sulphur print in that the impression did not consist of a series of dots but rather of a uniform stain. Evidently the sulphur does not exist as separate particles of either iron or manganese sulphide disseminated through the mass of the steel; apparently it exists in solid solution.

Thermally, the effect of the chromium is to raise the temperature at which the critical ranges occur. The Ac1 point occurs in the range 800°—830° C., and on cooling sufficiently slowly to prevent any hardening effects, the critical temperature change on cooling (Ar1) is found at about 750° C.

Stainless steel possesses notable air-hardening properties. A sample one inch or so in diameter, if allowed to cool freely in the air from 900° C., will have a Brinell hardness number of the order of 500. The capacity of the steel to harden increases with the temperature to which it is heated. In other words, the speed of cooling necessary to harden the steel becomes slower as the temperature to which it is heated rises (providing the latter is, of course, above the carbon change-point); also, slower rates of cooling are necessary to soften or anneal the steel when cooled from progressively higher temperatures.

The property of air-hardening is very useful in a steel. Apart from the obvious fact that less drastic methods of quenching are required (with the attendant lessened danger of cracks, warping, or other undesirable attributes of water-quenching), the slower rate of cooling necessary to harden the steel permits samples of large section to be hardened throughout. It also lessens the danger of soft spots due to retarded quenching. Anyone who has had experience in producing a glass-hard surface over a considerable area in an article made of ordinary carbon steel will appreciate the meaning of the last sentence. Owing to its air-hardening properties, however, the steel requires care during the course of manufacture. Billets, bars, forgings, or stampings are usually heated to at least 1000° C. before any operations are carried out, and if the material after being worked is allowed to cool down on the shop floor it will, when cold, be in the hardened condition and will be quite as liable to crack if rapidly or unevenly heated again as any hardened piece of tool steel. Being hard, it will require softening before any chipping, filing, or machining can be done. These troubles, however, may be avoided by allowing the forged, rolled, or stamped article to cool slowly over the range 800°—600° C. in order that the carbon change may take place and the steel thus bcomes soft.

Stainless steels which contain more carbon than that indicated above, if quenched or air-cooled from high temperatures, are comparatively soft to the Brinell test owing to the production of austenite. Such steels, though soft, are unmachinable, the material becoming hard when stressed. Austenitic samples also harden when tempered at about 600° C.; for instance, an actual sample had a Brinell hardness number of 270 when water-quenched, and one of 444 after being tempered at 600° C. Such hardening after tempering has been noticed by several cutlery manufacturers who have, by accident or otherwise, hardened their knife blades from too high a temperature. Such a practice, however, is not to be recommended, as a coarse grain is thereby produced in the knife blade.

Stainless steel is tempered in the same way as ordinary steel, but higher temperatures are required. A corresponding series of temper colors are formed at the higher temperatures necessary to soften the steel. For example, the following colors were obtained, at the temperatures indicated, on a hardened sample of the steel:

Straw	300° C.
Brown	400° C.
Reddish purple	500° C.
Light blue	600° C.
Bluish violet	650° C.
Grayish violet	700° C.
Gray	750° C.

Stainless steel has its maximum resistance to corrosion when in the hardened condition. It is then practically unaffected by exposure to moist air, fresh or salt water, or to such organic acids as occur in fruits. Samples buried in soil for three months have retained their original polish, and others have been immersed in vinegar or salt water for days without showing the slightest signs of attack. Tempering the hardened sample up to about 50° C. does not affect its resistance appreciably. Such tempering has also little effect on its hardness. Tempering at higher temperatures lowers the resistance

*From the *Journal of the Society of Chemical Industry,* Nov. 30, 1920, and *Chemical News,* Dec. 31, 1920.

[1]The word "stainless" has been retained because it is in general use; "unstainable" is, of course, the correct term.—Ed.

to corrosion, but even in the soft condition the metal is only slowly attacked. Such soft material, for example, is stained by vinegar, but a sample weighing 60 grms. only lost 0.04 g. after three weeks' immersion. A sample of nickel-chrome steel hardened and tempered so as to give the same tensile strength lost during the same time 25 times as much.

Nitric acid, strong or weak, does not dissolve stainless steel either in the hard or soft condition, nor is the steel attacked by concentrated or dilute solutions of ammonia, nor in a moist atmosphere containing ammonia fumes. Sulphuric and hydrochloric acids attack it readily; a 10 per cent solution of the latter in alcohol forms a convenient etching reagent for microscopic work. Dilute solutions of sulphuric acid, at ordinary temperatures, attack stainless steel considerably faster than ordinary mild steel.

The opinion has been held that the non-corrosible properties of stainless steel are only obtained when it is highly polished and that they are then confined to the surface. This is not correct. It is well known that metals in general have an increased tendency to corrode after they have been cold-worked. Stainless steel is no exception. Turnings of this steel are in a highly distorted condition and hence will rust. Similarly, the surface of a bar from which heavy cuts have been taken is distorted and is more likely to rust than one from which a fine finishing cut has been taken. A ground or polished surface will be still more immune. That polish, however, is not essential is shown by the resistance to corrosion exhibited by a fractured surface which has been obtained without distortion.

In addition to its resistance to corroding influences, stainless steel does not scale to any extent when heated at any temperature up to 800°—850° C. A sample heated for seven days in the range 700°—825° C. lost 0.7 per cent of its weight, whereas a piece of ordinary steel heated with it lost 17 per cent.

The suitability of any new type of steel for use in engineering work of any description is largely judged by its behavior under mechanical tests. A short description of the results of such tests on stainless steel will be of interest. After oil- or air-hardening from a temperature of 900° C., followed preferably by slight tempering at 200°—400° C., stainless steel has mechanical properties comparable with those of the well-known "100-ton" air-hardening nickel-chrome steel. When tempered in the range 650°—750° C., it gives tests highly suitable for many engineering purposes. The values obtained depend on the composition of the steel, but in general are in the following ranges:

Yield point	30—55 tons per sq. inch
Maximum stress	45—65 tons per sq. inch
Elongation	15—28 per cent
Reduction of area	35—65 per cent
Izod impact	25—70 foot-lb.

Tempering in this range of temperature (650°—750° C.) is also interesting commercially in that the hardness, and therefore the tensile strength only falls very slightly as the temperature increases. When a number of articles have to be tempered to produce a given tensile strength, quite a wide range tempering temperature is permissible—obviously a desirable thing commercially. On the other hand the hardness falls very rapidly in the range of 550°—650° C., and the difficulties of tempering in this range are correspondingly great.

During the war the great bulk of the stainless steel produced was used for airplane valves. Its value for this purpose lay, apart from its non-scaling property, in its superior strength at a red heat. The exhaust valves, especially of some of the large aero engines, frequently reach a temperature of 750° or 800° C., or even higher, and it is necessary that the valve should have sufficient strength at such a temperature to secure that the stem does not elongate during running. Actual tests obtained on testing mild steel and stainless steel at high temperatures gave the following figures:

Tensile strength at	Mild steel	Stainless steel
600° C.	11.84	24.24
700° C.	6.8	12.08
800° C.	5.04	6.64
850° C.	4.12	6.64

By increasing the carbon content of stainless steel, still higher values may be obtained, *e.g.*, 15—17 tons at 700° C. and 7.5—8.5 tons at 800° C.

The development of the uses of stainless steel was very largely held up during the war, since practically the whole of the steel made was used for war purposes. It may be confidently expected, however, that the near future will bring about a very noticeable development in the number and variety of its applications. It will also be found that stainless steel is not one steel but a group of steels. Just as in the far-off days "steel" was regarded as a hard product of iron, and little or no attempt was made to grade it into harder or softer varieties, so at present stainless steel is to most people a product having only one distinct set of properties, many regarding it solely as a special type of cutlery steel. In times gone by, as the use of steel became more general, it was realized that by varying the content of carbon or manganese, steels of widely different intrinsic hardness could be produced, and for each purpose some definite "temper" of steel was best suited. In the same way, as the use of stainless steel becomes more general, it will be found that products of different intrinsic hardness (corresponding to the varieties of ordinary steel) can be produced, all of them having the distinguishing property of great resistance to corrosion, but varying among themselves as soft or mild steel differs from file steel. For each use of stainless steel there will be an optimum "temper."

HYDROELECTRIC PLANT OPERATING UNDER A 5,400-FT. HEAD

What is probably the highest-head hydroelectric plant in the world is installed at Fully, Switzerland, operating at a net head of 1,650 m. (5,412 ft.). The installation is near Martigny, in the Rhone Valley, and operates from an Alpine lake 2,150 m. (7,000 ft.) above sea level. The Pelton wheels are fed by a pipe line about 4.6 km. (2.85 miles) in length. This is connected to a tunnel 500 m. (550 yd.) long, which is partly under pressure. The generating station contains four wheels, each of 3,000 horsepower, which run at 500 r.p.m.

Each bucket is exposed more than eight times a second to the blow of the jet leaving the pipe at a velocity of about 180 m. (590 ft.) per second. The wheels therefore had to be designed with extreme care. These wheels have an over-all diameter of 3.715 m. (12 ft.) and are of forged steel. They carry fifty-four buckets each and are so designed that no part either of the disk or the buckets is subjected to a higher tension than 1,000 kg. per square centimeter (14,200 lb. per square inch). Even in case of runaway this takes care of a speed 50 per cent above normal. The buckets are carried in a mortised groove and are fixed tangentially by formed keys driven axially between them. The whole makes a very rigid assembly with the disk.

Water from the feed pipe is conducted to each turbine by a cast-steel pipe 250 mm. (10 in.) in diameter, provided with a manually operated equilibrium valve. The jet pipe fixed to the bedplate under the turbine has a nozzle of tempered steel, the water discharge from which is regulated by a steel needle which moves in the axis of the jet pipe. The needle is always inclined to open when affected by the water pressure. It can be closed by a hand-operated screw, by oil-pressure mechanism or by the automatic governor. A cast-steel deflector placed between the nozzle and the bucket wheel is raised or lowered by the action of the governor, and when lowered causes a deviation of the jet away from the bucket wheel. The governing action is said to be particularly sensitive.—Abstracted from *Engineering* (London), Dec. 24, 1920, through the *Electrical World*, March 5, 1921.

The Salt Wells of China

Primitive Apparatus Used for Sinking Wells and Drawing Up the Brine

By Robert G. Skerrett

EVEN though China does trail in the march of civilization, still her people give to the fair-minded Occidental ample warrant for admiring wonderment.

For centuries upon centuries those ingenious Orientals have applied with exceeding cleverness the fundamentals of physics and mechanics to the mastering of many difficult tasks. In some of their engineering achievements they have indubitably set the pace in much that is commonly deemed essentially modern among us. In none of her varied activities does China show this more strikingly than in the prosecution of certain departments of her very important salt industry.

Probably a thousand years or so before we bored in search of oil, gas, water, etc., the Chinese were drilling deep into the geological strata in their quest for greater supplies of indispensable salt. This was especially the case in the provinces remote from the sea where it was not possible for them to satisfy the demand by simply evaporating the ocean's abundant brine or similarly treating the outpourings of springs carrying a saline charge. To tap the subterranean store, the Chinese in the less favored districts have been obliged to bore to a depth of quite 4,000 feet; and to gain their goal they have had to penetrate through successive layers of interposed rock.

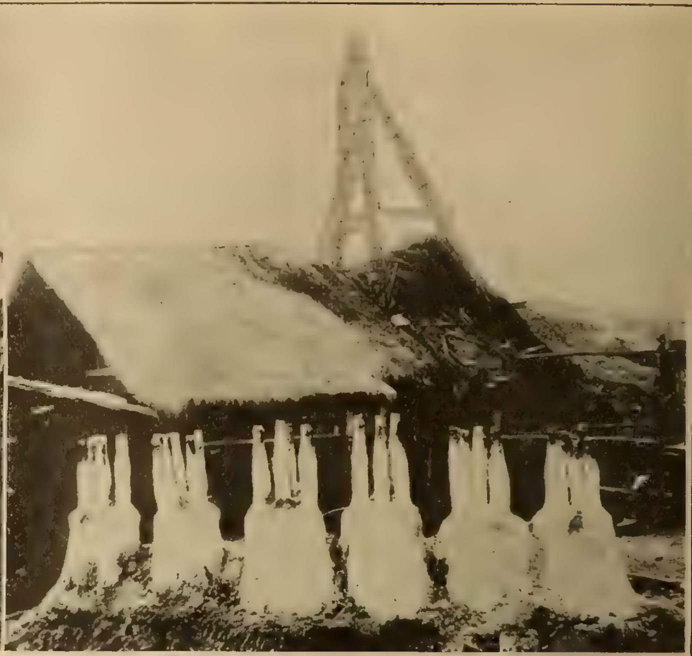
That they have succeeded in those undertakings is all the more remarkable when we contrast their primitive facilities with the instruments and apparatus which we now employ in kindred operations. True, we reach our objective quicker, but even so the driving of a well of comparable magnitude is an expensive job and we muster to its execution special tools skilfully fashioned and use drills made fit for their exacting work by the research of the metallurgist. Cables carefully manufactured for the purpose carry the load of the suspended metal implements, and the strands of these hawsers must be strong and elastic enough to bear the alternating stresses set up by the steel masses as they are lifted and dropped in pounding their way downward into the bowels of the earth.

And then, in order to handle the heavy weights involved, we have devised power-driven machinery capable of operating hour in and hour out, day after day, with a minimum of human supervision. Ruggedness and dependability are the outstanding characteristics of the apparatus, and the attendants always have at their disposal enough mechanical energy to minimize the burden laid upon their muscles. According to the method adopted, gas, oil, or steam may furnish the primary power; and the electric motor is now figuring in this field of industry. And how does the Chinaman attain his end; and what are the aids which he depends upon?

But before describing his age-old appliances and practices it might be well to sketch in a general way the salt industry of

SALT BEING WEIGHED IN THE PRESENCE OF A GOVERNMENT OFFICIAL. THE SALT INDUSTRY IS HEAVILY TAXED

HAULING THE BRINE UP A TRESTLE FROM WHICH IT FLOWS THROUGH BAMBOO PIPES TO THE EVAPORATORS



CEMENT-COVERED BAMBOO JETS OF A GAS WELL. THE GAS IS USED IN EVAPORATING WATER FROM THE BRINE

China so that we may visualize its outstanding significance in the economic life of the nation. This will increase our astonishment at the Oriental reluctance to adopt up-to-date equipment in prosecuting the business. Normally, the domestic output of salt in the United States is in the neighborhood of 5,000,000 tons and represents a value of approximately $12,000,000 annually; while in China, ordinarily, the tax alone each twelvemonth on salt is several times this sum. Plainly the industry is of monumental proportions.

China's salt gabelle is an institution of antiquity, and for many centuries the salt trade of that country has been a government monopoly. Indeed, the income derived in this way has more than once figured as a prime factor in guaranteeing loans made by foreign nations. This is not hard to understand if we bear in mind how the revenue was garnered. Before the establishment of the Chinese Republic the management of the salt tax was a subject on which little information was available. At that time China was divided, for purposes of administration, into eleven salt areas, seven of which produced sea salt, two lake salt, and two well salt; and these zones were subdivided into numerous districts—the object being to equalize in a measure the natural advantages or conditions prevalent in the several regions.

Then the government, besides levying a tax upon the salt, acted the while as middleman between the producer and the retailer, and not infrequently played the part of transportation agent and wholesaler; and the authorities did not hesitate to put upon the traffic all that it would bear. Salt has paid as many as forty-three different taxes during the various transactions between the producer and the ultimate consumer. These abuses have been modified since 1913, when the Chinese Republic secured an international loan of $125,000,000 and offered the salt revenue as a security. Following that arrangement, the whole administration of the salt levy was reorganized, and the appreciation of silver has added greatly to the value of the income since 1914. The total revenues from the salt gabelle in 1916—the latest data available—amounted to $72,440,559, Mexican. China jealously guards the whole salt trade, and strictly prohibits the importation of any of this material.

The two most interesting phases of the production of salt in China are those exemplified in the procedures followed, respectively, in the provinces of Hankow and Szechwan, where the brine is raised to the surface from considerable depths. In the Hankow district the annual output is about 15,000 tons and this is obtained from a region where gypsum has been worked for quite two centuries. Salt, *i.e.*, sodium chloride, is a fairly common accompaniment of gypsum deposits; and the salt-yielding layers in Hankow lie at depths ranging from 400 to 900 feet. The mineral is reached by sinking vertical shafts. The usual practice is to mine for gypsum for two or three years and then to close the pit for a period of twelve months, during which time brine is the outcome of natural leakage or is formed artificially by pouring water into the galleries, whence it flows down the slopes of the excavations which follow the dip of the gypsum.

Geologically, the salt is either held in the pores of the soft rock or it lies interspersed as sheets between the gypsum, and in breaking out the rock the salt is exposed so that the inundating water can penetrate and dissolve it. At the end of a twelvemonth sufficient brine accumulates to furnish work for from one to five months, after which the gypsum is again mined for an interval of two or more years. In this way the removal of gypsum and the leaching out of the salt go on alternately.

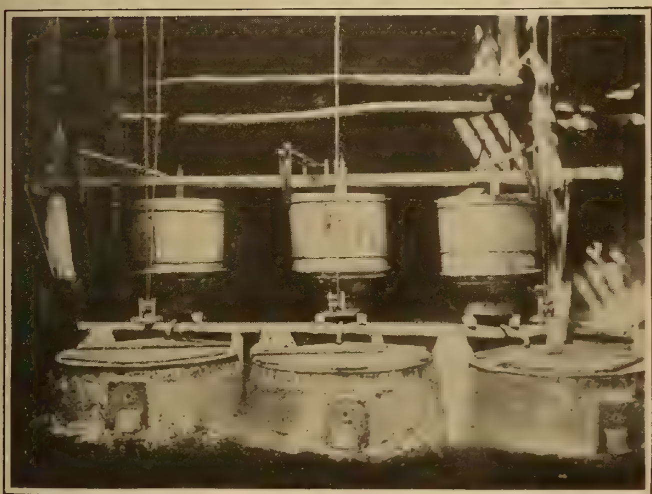
The brine is raised to the surface by a simple windless and a rope to which wooden buckets are attached, and at the pit mouth the salty fluid is poured into nearby large wooden tanks sunk into the ground. From these reservoirs it is baled out into troughs, covered by mats, and these conduits convey it a distance of a few hundred yards to the furnaces, where the brine is boiled in iron pans to stimulate the evaporation of the water. These pans are disposed in batteries of from three to five to a furnace, and are set up beneath tiled sheds with open sides. The pans are made of boiler plate and are three feet in diameter and eighteen inches deep. The furnaces are built in pits lined with brick and are arranged so that the boiling pans are just above the ground level. The fuel is coal procured in the neighborhood of Hankow.

Coolies ladle the fresh brine into the caldrons, and as the fluid boils incessantly the water is rapidly vaporized. The salt precipitates as the density of the liquid increases, and at the proper stage the deposit is dipped out and dumped into split bamboo baskets. The salt thus produced is distributed to the consuming areas by small dealers who carry it about in two baskets slung at the end of a pole—the total load being around 100 pounds. The salt so manufactured is snow white, very fine, crystalline and of good flavor, though slightly bitter. This is probably due to the presence of an excess of magnesium. Apart from using salt for seasoning his food,

feeding livestock, etc., the Chinese employ it to preserve both meats and vegetables, and the nation at large requires immense quantities for this purpose.

Beyond question it is in the province of Szechwan that Chinese ingenuity shows at its best in the production of salt. There, fully 1,100 miles up the Yang-tze-Kiang from the sea, the Chinese have gone down anywhere from 2,000 to 4.000 feet in quest of brine; and in the course of a year they manufacture on an average substantially 385,000 tons of the commodity. Szechwan is able not only to supply the salt needs of its own millions of inhabitants but it sends annually into near-by provinces a matter of 82,000 tons of the stuff.

The leading producing centers of salt in the province of Szechwan are Tzuliuching and Wutungchiao. The wells



INTERIOR OF AN EVAPORATING HOUSE

around Tzuliuching are by far the most important, and are able to furnish about half of all of the salt obtained in the province. The boring of a well does not differ in principle from that commonly practiced in the search for oil and gas in this country, but the agencies relied upon are notably dissimilar. It is not hard to understand this when we grasp the somewhat isolated position of the province of Szechwan. It lies beyond the gorges and rapids of the Upper Yang-tze, and that waterway has for ages been the main route of commercial intercourse. Inasmuch as freight rates by that dangerous and tedious channel of trade are very high, and goods often have to be packed for some distance by man and beast, there was little inducement in the decades gone to introduce machinery which was sure to be too costly. Therefore, the Chinese owners of a salt concession wisely elected to depend as much as possible upon the brawn of the willing coolie who could be hired for a pittance.

To make sure that the bore of his well is vertical, the Chinaman has adopted a very effective means of steering his drill straight down at the start and of forcibly directing its course for a while thereafter. To this end it is customary for him to excavate a shaft to a depth of 200 feet, and in the center of this he sets upright and steadies by rock ballast a number of nicely hollowed-out tree trunks joined together to constitute a single wooden pipe. The upper portal of this guideway is protected by a limestone cap pierced with a 10-inch hole. With this installation complete the actual drilling of the well is begun.

Instead of the towering derricks characteristic of our oil fields, the Chinaman substitutes a low framework which supports a lever pivoted so that it may move in the vertical plane. At the short end of this pole is hung the drill rope with its pendant tools. Parallel with the longer arm of the lever are two benches—one on either side, and upon these the men stand who operate the "jumping beam." By stepping on the lever it is depressed and the drill raised a foot in the shaft. Next, when the coolies hop off, the drill drops as the long arm of the lever rises. The number of men needful for this work is regulated by the load represented by the tools and the weight of the connecting line. The beam gang is divided into two squads, one on either bench, facing each other. The several men place their right feet on the lever, and at the word "go" all of them step with their left feet across and on to the neighboring bench, withdrawing the while their weight from the beam. Promptly all hands swing around and repeat this operation, and in the course of a minute the lever can thus be raised and dropped from ten to twenty times—the drill hammering away under ground in unison. This interesting method of well drilling is illustrated in the frontispiece of this number.

The drill is generally a 12-foot bar of iron having a cutting face with a spread of 4 inches, and the tool weighs about 200 pounds. Above this drill is suspended another bar encased in bamboo, and its function is to add to the blow of the descending drill something after the fashion of the "drilling jars" used in our oil and gas fields. It supplements the hammer blow of the drill and, also, helps to jerk the drill free from the rock on the upward pull of the cable. The latter is not fashioned of hemp, as one might suppose, but is made up of strands of split bamboo—commonly three of them, and this line is secured by a length of Manila rope to a hook engaging an iron eye on the short arm of the beam. The lower end of this hook has a heart-shaped grip, and every time the drill is raised the operative at the well mouth gives it a half twist, and in this manner causes each succeeding

SOME OF THE PRIMITIVE TOOLS USED FOR RECOVERING LOST DRILLS, SINKER BARS, ETC.

blow of the drill to strike at a different angle. This insures the boring of a round hole and tends to make the jamming of the drill less likely.

After ten minutes of hopping on and off the "jumping beam," the coolies rest while the drill rope is being lengthened. Apparently the eight-hour-day is the rule in that section of China, because three shifts are employed to keep the work going night and day. The hole is deepened at an average rate of 3 feet every twenty-four hours. The cost of drilling a well varies according to the depth, and is said to run from $2,000 to $17,000. If nothing unforeseen happens to interfere with the execution of the task, it is possible to drive a

well in from three to five years, but this may be much prolonged by tools breaking off in the hole, by the inundation of the well by subterranean streams, and by the halting of operations through all too frequent litigation. Indeed, with these contingencies arising, the successful completion of a well may involve a period of anywhere from ten to twenty years. In a country where time counts for little this does not dismay, and it is a fact that native capitalists look with marked favor upon salt well enterprises though it may be a decade or so before anything is realized on the investment.

Should water enter from an underground source during drilling, the Orientals resort to a well-tried remedy. A plug or wad of coarse grass is forced down the bore to a point below the leak, and on top of this obstruction is poured a composition of lime, clay, and wood oil. This mixture hardens rapidly, effectually closes the water-bearing seam, and is subsequently pierced by the drill in its deeper quest for the salty store.

Chinese engineers have shown much cunning in devising tools for the recovery of drills, etc., which have been lost by the breaking of the bamboo line, and these are so patterned that they will meet successfully well-nigh every accidental condition. They range from heavily weighted spears to single and triple rods carrying one or more barbs calculated to catch some part of the lost gear and make it practicable to retrieve it.

With the well bored and the deeply-lying brine reached, then comes the problem of raising the salt-laden fluid to the ground's surface, 1,000, 2,000, 3,000, or 4,000 feet above. The bailers are formed of sections of bamboo having a diameter of four inches, and a number of these are joined together to constitute a container from 50 to 100 feet long. They are reinforced frequently with windings of wire and twine, and have capacities of from 300 to 600 pounds of brine. The bailers are drawn up by means of buffalo winches upon which are wound the bamboo-ribbon ropes to which the bailers are attached. A lift from a deep well requires ten or twenty minutes; and so hard are the buffaloes worked that they are allowed to rest for several hours after they have raised the bucket twice.

When the brine has been brought up to the surface, the fluid, if the dip of the land permits, flows by gravity to the evaporator houses, being distributed through bamboo pipe lines which are made water-tight at the joints with windings of shredded bamboo and Chinese cement. Should the well mouth be below the evaporator sheds, the brine is elevated by one or more "dragon-bone lifts," *i.e.*, wooden chain pumps, or carried by coolies to a tank upon a raised trestle whence it may feed downward through bamboo conduits for possibly a thousand feet or more. The evaporator pans in the Szechwan district are heated by natural gas, which is frequently encountered when driving salt wells. The Chinese do not cap their wells in the usual acceptation of the term, but they build a gas-collecting chamber around the top of the well, and from there lead the gas through bamboo pipes to the burners beneath the iron pans. The burners are formed of bamboo and are enveloped in cement made of lime, granulated tiling, and sand or mud. On the roof of the gas-collecting chamber are mounted similar burners, and these are lighted to stimulate combustion when the gas pressure rises beyond that needed to supply the evaporator jets. The Chinese do not use valves to regulate the emission of the gas, but allow it to burn steadily at all the burners when there is enough of it, and simply cover up some of these when the supply begins to wane.

It is a matter of record in the salt industry of the United States that the machinery and metal equipment deteriorate rapidly. Therefore, the Chinaman with his simple apparatus, for the most part of wood and vegetable fiber, has adopted mediums calculated to last fairly well and to be easy of replacement. However, more modern facilities are winning recognition in the Tzuliuching district, and steam hoists have gained a foothold. The first of these was introduced about 1915, when an epidemic among the buffaloes and oxen threatened to halt activities. The steam plants are built in Hankow and Shanghai, and steel rope is sent to the salt wells from the United States. The salt is produced at a cost of about half a cent a pound, and the laborers are paid around $2.50 a month, their food being furnished gratis.

PHYSICAL PROPERTIES OF ICE

Professor Motonori Matsuyama of the Kyoto Imperial University, Japan, publishes in the October-November number of *The Journal of Geology* the results of his investigations carried on at the University of Chicago on "Some Physical Properties of Ice."

In introducing his article the author says: "The motion of an ice sheet along the mountain slopes and over a large area of the continent may be caused by more or less different forces. Besides the external forces it is also important to know what is the behavior of the ice itself in such motion. Numerous works have been published on these problems, among which those of McConnell and Mügge are famous and have been referred to by many authors. According to them an ice crystal can be sheared more easily in the direction parallel to the basal plane than in any other direction."

The author's own experimental investigations covered such problems as that of the determination of the *Limit of Elasticity, the Modulus of Rigidity, the Ratio of the Stress to the Strain, Torsion by Constant Force, Torsion by Increasing Force, Bending* and *Crystalline Structure.*

The author finds:

(1) In some specimens of ice a sharply defined elastic limit was noted, though in other cases it was not so clearly shown.

(2) The modulus of rigidity of ice, when the crystals are perpendicular to the axis of the test piece, is very small compared to that of metals, and is about 2×10^6 c.g.s. There is a slight indication that it is greater when the shearing is parallel to the base of the constituent crystals than when it is perpendicular.

(3) The Young's modulus is also very small compared to that of metals. It is largest when the crystals are parallel to the length of the test piece, and has the numerical value about 20×10^{-6} c.g.s.

(4) Elastic fatigue was marked after repeated torsion. On account of the fact that it was often necessary to use certain bars in successive experiments during which they suffered from different amounts of fatigue, it was difficult to compare the results bearing on ice bars with crystals parallel and perpendicular to the length of the test piece. Still there were some indications that beyond the limit of elasticity the former orientation was stronger than the latter against torsion. In the case of bending experiments, this was clearly shown.

(5) The torsional deformations both by constant and by increasing forces were observed and the result is shown by curves, though no mathematical conclusions were made. The recovery curves showed that the observation was approaching the stage where no recovery would take place after removal of the force.

(6) When an ice bar with crystals parallel to its length was bent, the bent portion showed the change of optical character, the extinction swinging around the curve. In each crystal when the bent specimen consisted of parallel crystals running horizontally across it, parallel straight lines were observed.

The conclusion is reached that these facts seem to show that gliding planes parallel to the base of each crystal are not the controlling factor in the deformation of ice and probably are not even an important factor. But instead, adjustments along the contact surfaces of adjacent crystals and perhaps the development of planes of weakness in the constituent crystals parallel to their long axis seem more effective in the process of deformation.

Toning Photographic Prints*

Methods Used to Bring Out the Shades and Shadows in Various Colors

THE toning operation has for its purpose the development of the shades and shadows in the ordinary photographic print by subjecting it to the action of various chemicals which produce different color effects in the picture. For this purpose, photographic papers are divided into two classes. The first class, called "direct printing papers" consist of those papers such as "silver citrate paper," "albuminous paper," "ordinary blueprint paper," "celloidine paper," "cello," etc., which print directly on exposure to light so that it is possible to watch the formation of the picture and stop it at any desired point. The second class of photographic paper must be developed after exposure before the picture appears. Such papers are "gelatin bromide, gelatin chloride, gelatin chlorobromide paper."

DIRECT PRINTING PAPERS

The active constituent of these papers consists of an emulsion of silver chloride in gelatin, albumen or colloidon in the presence of citric acid and an excess of a soluble silver salt (citrate or nitrate). The latter absorbs the chlorine, disengaged in the decomposition of the silver chloride by exposure to light. The soluble silver salts are removed by washing and the undecomposed chloride of silver by means of a "hypo" bath. At the same time the subchloride of silver (Ag_2Cl), which forms the image, is converted into the chloride of silver and the metal itself:

$$Ag_2Cl = AgCl + Ag.$$

The picture produced is brownish purple in color at first, changing into a reddish yellow tone after fixation. The toning operation improves the color of the picture, and, what is more, lends permanency to it.

TONING OF DIRECT PRINTING PAPERS

This is accomplished entirely by the aid of gold and platinum salts, and also the salts of the platinum group of metals. The colors that are obtained lie between black and brown, in reddish, bluish or purplish shades. Toning can be effected before or after fixing.

GOLD TONING

Either auric chloride ($AuCl_3$) or protochloride of gold ($AuCl$) can be used for this purpose, preferably the latter. for then the clearness of the picture is not impaired by the substitution of too much of the gold for the original silver. The reactions, taking place, are as follows:

$$AuCl_3 + Ag = 3AgCl + Au.$$
$$AuCl + Ag = AgCl + Au.$$

The color of the picture varies from an orange red to a violet black, according to the quantity of gold that replaces the silver. The degree of the alkalinity or the acidity of the toning bath affects the tints in the picture as well. One point that must be observed carefully is that the excess of the soluble silver salt (silver nitrate or silver citrate) must be washed out before the toning operation, as otherwise the gold chloride is decomposed and a part of the gold is rendered useless for toning.

PREPARATION OF THE TONING BATHS

The bath is made by adding a weak alkaline reagent such as bicarbonate of soda, acetate of soda, borax, magnesia, carbonate of lime, etc., to a solution of auric chloride until the yellow color of the same has disappeared, indicating the transformation of the salt into the protochloride of gold ($AuCl$) which is colorless. It is very important that the toning bath be either neutral or what is better slightly acid. If the bath is alkaline the excess of the alkali decomposes the active principal $AuCl$ to form suboxide of gold (Au_2O). This black powder then discolors in the alkali to form a subaurite of gold, which is colorless but without any action in toning. The more alkaline the bath, the more rapidly it loses its potency. For this reason the use of sodium acetate is preferred in that it leaves the bath slightly acid. The insoluble basic compounds such as $CaCo_3$, give neutral toning baths, which keep their effectiveness much longer than the alkaline baths and are just as potent.

TONING AND FIXING COMBINED

It is possible to accomplish both the operations of toning and fixing in one bath. The bath must contain (1) chloride of gold and (2) sodium thiosulphate (hypo). The function of the latter is not only to dissolve the $AgCl$ but to form a hyposulphite of gold and sodium with $AuCl_3$, which then forms the active principle of the toning bath.

Various other substances may be added to the bath as follows:

(a) Alum, to tan the gelatin. [Formalin is preferable to alum for this purpose, as alum reacts with $Na_2S_2O_3$ (hypo)]

(b) Acetate of soda, to avoid the precipitation of sulphur as a result of the above reaction.

(c) Lead salts (acetate or nitrate) to increase the potency of the toning bath.

The action of the lead salts is very much like that of a catalyst, as a very small quantity will promote the deposition of a large amount of gold. It is known that the reactions that take place are very complex and that a large variety of compounds are formed. It appears that the lead first replaces a part of the silver in the picture, which is then replaced more readily by gold.

The lack of permanency in photographs subjected to the combined action of a toning-fixing bath has been known for some time. This has been found to be due to the hypo left behind on the print. Careful washing will eliminate all traces of the salt and give pictures which are lasting.

TONING IN PLATINUM

Photographs may be toned in platinum directly from the silver image or else from the gold toned image. Blacker shades are obtained than with gold. The platinum salt used for this purpose is potassium chlorplatinate and the reaction that ensues is as follows:

$$PtCl_2\ 2\ KCL + 2\ Ag = 2\ AgCl + 2\ KCl + Pt.$$

It is essential that the bath be acid. It is preferable to acidify by means of the mineral acids, such as sulphuric and phosphoric, as the organic acids are reduced with precipitation of platinum. The combined toning-fixing bath cannot be used for the reason that the acid in the solution would decompose the hypo. Salts of other metals in the platinum group, such as palladium, iridium and osmium, act in a similar manner. The chlorpallodiate of potassium has been used as a substitute for platinum for economical reasons. Nitric acid, being a strong oxidizing agent, cannot be used in platinum toning.

Gold-toning baths become inactive when the Au content is reduced to 30 per cent. Platinum baths can be exhausted to a far greater degree before becoming impotent, the platinum content being 11 per cent at that point. Silver pictures toned

*Translated for the *Scientific American Monthly* from *Chimie et Industrie*, 1920, 3, 10.

with platinum still contain about 25 to 30 per cent of the original silver. In gold toning the silver content is very much higher.

MODIFYING THE COLOR BY PHYSICAL DEVELOPMENT

A wide range of color tones can be obtained by subjecting photographs on print paper which has been exposed only slightly to light to the action of physical developers. Much finer results are obtained than in the toning process. The distinction between physical and chemical developers lies in the fact that the toning effected by the former does not involve any chemical change in the image, such as the substitution of one metal for another. (Au and Pt for Ag.)

The process is somewhat as follows: The picture is printed from the negative until just the faint outlines of the image are perceptible. Then it is treated with a developer, consisting, for example, of 100 parts of water, 1 part of metol (metol is a trade name for a photographic developer. Its chemical name is methyl pora-amino—phenol sulphate), and 10 parts of a concentrated solution of gum (gum-water). The color of the picture varies according to the time of exposure in printing and to the time of development.

The one important disadvantage of this process is that the colors that are produced by it are very variable in nature. The tones run the gamut from bluish black to black. The developer intensifies the color of the photograph, acting on the silver salt contained in the print paper. After development the picture is washed and fixed in a bath of hypo. The gum acts as a colloid in retarding the reduction of the soluble silver salt and in mitigating the action of the physical developer.

PHOTOGRAPHIC PAPERS REQUIRING DEVELOPERS

The active principal in these papers consists of an emulsion of silver bromide or silver chlorobromide in gelatin. The paper is exposed to the action of light for a short time and the image is brought out by means of chemical developers in a manner similar to the development of negatives.

VARIATION OF THE COLOR OF THE PHOTOGRAPH BY DEVELOPMENT

The color of the picture can be varied by modifying the composition of the developer. The gelatin-silver chlorobromide papers are very much more susceptible to such toning than the gelatin-silver bromide papers. The shades run from a warm brown to a black in the latter case, while in the former greenish black tones, brown green, sepia, blood red colors are obtained by varying the time of exposure, the dilution of the developer and the duration of the development. The difference in color is due only to variation in the size of the grains of the silver, reduced by the developer.

PROCESSES OF TONING DEVELOPED PICTURES

These processes are classed as follows:

(a) Toning by means of various metallic salts;

(b) By sulphuration of the silver;

(c) By fixation of coloring matters on the silver after its transformation into compounds, acting as mordants;

(d) By the action of quinone and an alkaline bromide.

TONING BY MEANS OF VARIOUS METALLIC SALTS

This is done by the aid of a solution containing potassium ferricyanide ($K_3Fe(CN)_6$) and a metallic salt whose ferrocyanide is insoluble. The silver in the photograph acts as a reducing agent, transforming the ferricyanide into ferrocyanide ($K_4Fe(CN)_6$) and silver ferrocyanide ($A9_4Fe(CN)_6$). The metallic salt in combination with the ferrocyanide of potassium gives a colored compound which produces the tone of the photograph.

The following conditions must be observed in order that the process prove successful:

1. The metallic salt must give a colored insoluble ferrocyanide.

2. The metallic salt must give a compound with $K_3Fe(CN)_6$, which is soluble in water or in a compound which is itself soluble in water and must be without any action on the silver of the photograph.

As silver ferrocyanide is formed by the reaction of $K_3Fe(Cn)_6$ and the soluble silver salt before the toning reaction, it is necessary that the solution contain a substance, capable of dissolving the $Ag_4Fe(CN)_6$ without attacking the colored ferrocyanide so as to prevent the deposition of the orange colored $Ag_4Fe(CN)_6$ on the white spaces in the photograph. The metallic salts used for this purpose are uranium, copper, iron, molybdenum, cobalt and vanadium compounds.

TONING IN BROWN AND BLOOD RED BY MEANS OF FERROCYANIDE OF URANIUM

Two uranium ferrocyanides are known:

A. $K_6Fe(CN)_6(UO_2)_5 + 12H_2O$.

B. $K_2Fe(CN)_6(UO_2)_3+6H_2O$.

A is a fire red compound quite soluble in water, formed by the addition of a diluted uranyl salt to a concentrated solution of $K_4Fe(CN)_6$ in excess. B is a brownish red insoluble salt, formed by adding the $K_4Fe(CN)_6$ to the uranium salt solution.

In this toning process two precautions must be taken. First, the solutions should be acidified with acetic acid and second too great an excess of $K_4Fe(CN)_6$ should be avoided. If the Ur salt is in excess, then a brownish red picture is obtained; when the $K_4Fe(CN)_6$ is in excess, the first ferrocyanide of Ur (A), which is soluble, tends to form.

The nitrate of uranium is used generally. The photograph is just dipped into the bath and as the Ur ferrocyanide is somewhat soluble in water, the picture is washed for a short time only.

TONING IN BLUE WITH FERRIC FERROCYANIDE

When a silver picture is treated with a concentrated solution of $K_3Fe(CN)_6$, containing ferric citrate or oxalate, the silver is replaced more or less completely by ferric ferrocyanide or Prussian blue ($Fe_4[Fe(CN)_6]_3$) resulting in the formation of a blue image. The choice of the ferric salt is important. Ferric chloride ($FeCl_3$) cannot be used as it forms silver chloride. The ferric ammonia citrate is used most of all.

The ferric salt should be freed completely of all ferrous compounds, as otherwise the bath becomes blue owing to the formation of ferrous ferricyanide ($Fe_3[Fe(CN)_6]_2$), which discolors the white spaces in the photograph. The washing with water should not be prolonged for any length of time, as the alkaline action of the water tends to decolorize the toned picture.

TONING IN PURPLE BY THE AID OF CUPRIC FERROCYANIDE

For this purpose the purplish red precipitate of cupric ferrocyanide ($Cu_4[Fe(CN)_6]_2$), formed by mixing solutions of $K_4Fe(CN)_6$ and a cupric salt is used. The toning bath contains the latter, $K_3Fe(CN)_6$ and a solvent of the cupric ferricyanide, which forms directly in the bath. Potassium citrate ($K_3C_6H_5O_7$) is added to prevent the formation of the ferricyanide, but at the same time it does not impair the formation of the ferrocyanide which is the toning principal. The following equation shows what happens:

$$\underset{\text{Ferricyanide}}{2Cu_3[Fe(CN)_6]_2} + 4Ag = \underset{\text{Ferrocyanide of silver}}{Ag_4Fe(CN)_6} + \underset{\text{Cupric Ferrocyanide}}{3Cu_2Fe(CN)_6}.$$

TONING IN REDDISH BROWN WITH MOLYBDENUM FERROCYANIDE

Ammonium molybdate, dissolved in acetic or oxalic acid, gives a reddish brown precipitate of molybdenum ferrocyanide with $K_4Fe(CN)_6$. The ferrocyanide dissolves in excess of $K_4Fe(CN)_6$ to form the double ferrocyanide of Mo and K. The Mo salt is used in a dilute solution. About 3 to 4% of $K_4Fe(CN)_6$ is added.

TONING IN VARIOUS COLOR BY USING MIXTURES OF FERROCYANIDES

The reddish uranium toned photograph can be shaded blue, more or less, by treatment with a ferric salt, which forms ferric ferrocyanide, replacing uranium ferrocyanide. The degree to which these substitutes can take place depends solely on the chemical properties of the various metallic ferrocyanides. The one that can be decomposed by a reagent can be replaced generally by the one that is not susceptible to decomposition.

Ammonia decomposes $Fe_4[Fe(CN)_6]_3$ but not $Cu_2Fe(CN)_6$. Hence, a picture toned in iron, when treated with an ammoniacal solution of a copper salt, can be made to assume any desirable intermediate shade between blue and reddish purple by stopping the replacement process at the proper point. It is also possible to tone photographs with certain metallic ferrocyanides which cannot act on the picture directly, but which can be substituted for the original silver of the image by the interposition of another ferrocyanide.

TONING WITH FERROCYANIDES IN TWO SEPARATE BATHS

The photograph may be dipped first in a solution of $K_3Fe(CN)_6$, whereat $Ag + Fe\ (CN)_6$ is formed and the excess $K_3Fe(CN)_6$ and $K + Fe(CN)_6$ is removed by washing. Then, any desired ferrocyanide can be formed on the image by a second immersion in a solution of the chloride of the metal. The AgCl that is precipitated and which dulls the picture can be removed by washing with a 5% hypo solution. This process admits of very general application.

TONING IN GREEN (FERROCYANIDE OF VA AND FE, AND FERROCYANIDE OF PB AND CO)

A dark green color tone can be obtained by immersing the photographs in a bath containing $K_3Fe(CN)_6$, vanadium chloride, perchloride of iron, oxalic acid and potassium oxalate. A bright green tone results when two baths are used. The first contains $K_3Fe(CN)_6$ and lead nitrate. This bleaches the picture forming lead ferrocyanide. Then, after the soluble lead salts are removed by washing, the picture is dipped in a solution of cobalt chloride, acidified with HCl.

TONING BY SULPHURATION OF THE SILVER

The process consists in transforming the silver of the photograph into stable sulphides of a brownish black to a sepia color. There are two methods which can be used. The first is to convert the silver directly into the sulphide and the second is to change it first into the chloride, bromide, or iodide and then into the sulphide.

TONING BY DIRECT SULPHURATION

Direct sulphuration is accomplished by the use of nascent sulphur or of the alkaline polysulphides.

Nascent sulphur may be prepared hot or cold. In the first case the photograph is treated first with formalin to prevent the gelatin from being injured by heat. The toning bath contains 50 grams of alum and 100 grams of hypo. When heated to 80° C. a reaction takes place which results in a deposition of nascent sulphur on the silver of the image. A sulphide is formed, toning the photograph. The white spots are not discolored. In using alkaline polysulphides, such as sodium bisulphide or liver of sulphur (a mixture of potassium salts and higher sulphides), it is found that discoloration does take place due to the sulphur being deposited on the white spaces in the photograph.

The process can take place in the cold by using colloidal sulphur. This is made by dissolving a mixture of $Na_2S_2O_3$ and a colloid (albumen, dextrin, gum arabic) in water and adding an acid, which decomposes the hypo, liberating the sulphur. The mixture becomes milky after a while and when this happens the picture is immersed therein. At first no change is noticed but after it has remained in the solution for 20 to 25 minutes and is then subjected to a prolonged washing, its color changes gradually to a brown and after an hour and a half of this treatment, the tone is developed fully. The whites of the photograph are not discolored. What probably happens is that the sulphur is retained by the gelatin in the photographic paper and does not react with the silver image until the metal has been converted into Ag_2O by the oxidizing action of the wash water, while at the same time the sulphur is changed into H_2S. Then reaction takes place with formation of silver sulphide (Ag_2S). It is also likely that oxysulphides are formed and the tints that are obtained correspond to the existing proportions of the two sulphur compounds.

TONING BY INDIRECT SULPHURATION

In this process the silver is first changed into the iodide or bromide by the action of a mixture containing $K_3Fe(CN)_6$ and KBr or KI. Insoluble silver ferrocyanide is formed first and $K_4Fe(CN)_6$; the alkaline halide transforms the $Ag_4Fe(CN)_6$ into AgBr or AgI. The soluble $K_4Fe(CN)_6$ is removed by washing, and then the photograph is immersed in a solution of an alkaline sulphide. Reaction is instantaneous, a brown colored image resulting. When a halide of a metal is used, which itself will give a colored sulphide, the tone is different from that given when that substance is absent.

Cupric chloride can be used above. Then AgCl and Cu_2Cl_2 are formed. The latter remains with the AgCl and reacts to give copper sulphide (CuS) in the further treatment. It is not possible to wash out all the $CuCl_2$ from the picture with the result that the white spots remain discolored slightly.

SULPHURATION WITH COMPLEX SULPHIDES

Instead of the alkaline sulphides, the sulphomolybdate of ammonia or the sulphoantimoniate of soda can be used. In this case warmer tones are obtained, due very likely to the fact that a certain quantity of the metal (Mo and Sb), which is combined with the sulphur, participates in the reaction.

TONING IN VARIOUS COLORS BY MEANS OF BASIC DYES

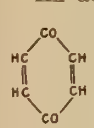
The silver of the image is not itself capable of combining with dyestuffs directly, but it is possible to fix a certain number of basic dyes on it, provided it is first converted either into the iodide or else into an indefinite chromium compound, formed by the action of $K_3Fe(CN)_6$ and chromic acid on the silver image. The picture is mordanted in this way and can be dyed permanently with basic colors. These tint the gelatin as well, but the color is removed easily by prolonged washing with water. The paper itself, however, always retains some of the dye.

Various shades of red can be obtained with Pyronine B. Fuchsine, etc., blues with Malachite Green, Methylene Green 6B, yellows with Phosphine, Orange Acridine R, etc., etc.

The colors combined with the silver image by the mordanting action of AgI possess different properties from those in the original state. Sodium bisulphite ($NaHSO_3$) discolorizes malachite green, but not when it is fixed on the photograph. For this reason it is possible to decolorize the background without injuring the tone of the picture.

TONING IN COLORS BY MEANS OF QUINONE AND AN ALKALINE BROMIDE

An aqueous solution of quinone plus sour alkaline bromide will modify the color of silver images. A whole series of colors varying from a brownish black to sepia can be obtained according to the duration of the toning treatment.



What happens is not understood very clearly. It is possible that the color is due to the formation of perbromide of silver, according to the following equation:

$$C_6H_4O_2 + 2KBr + Ag = C_6H_4(OK)_2 + AgBr_2$$

Quinone	Potassium salt of hydroquinone	Silver perbromide

The analysis of the toned image has not confirmed the accuracy of this equation.

Evolution of the Golf Ball

From the Primitive Feather Ball to the Rubber-Wound Ball of Today

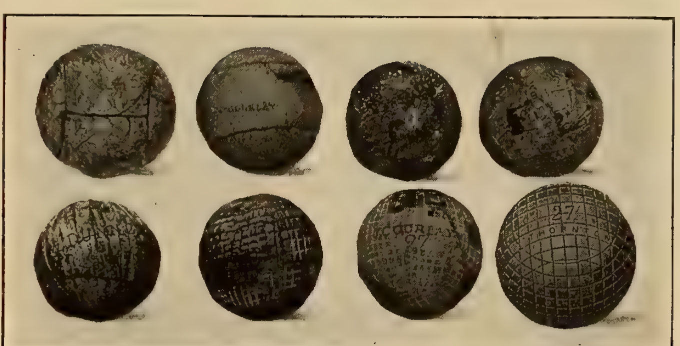
By Thomas C. Turner

THE Royal and Ancient Game of Scotland is a title often given to the game of golf, and it is well justified, at least, as regards antiquity, for few pastimes can antedate golf, and few if any can surpass it in popularity. With the exception of football, baseball and cricket no outdoor sport has so large a following, and yet as a popular game it is comparatively new, for in its early days it was, as its title implies, quite exclusive.

The first mention of golf comes to us in the form of an ordinance of the Scotch Parliament of 1457, when the game was very evidently played with such popular zeal as to give the impression that it might interfere with the then necessary training in archery, and at such periods as were set for this training the decree forbade the playing of *futeball* and *golfe*. For four hundred years following this the game remained almost entirely in its native land. Even by 1875 the Royal and Ancient game had made very little progress south of Scotland, with the exception of Blackheath Club, the Westward Ho of North Devon, the Royal Liverpool Club of Hoylake, and the Wimbledon Club, few clubs existed. In that year small courses were laid out both for the Oxford and Cambridge University Golf Clubs. At last the game took a sudden and popular hold, and by 1890 golf was the fashion.

It is not much over thirty years since its first appearance was made in America, for it was in 1894 that the first amateur championship was played over the old St. Andrews Golf Club course at Yonkers. The year following this the first amateur championship played under the auspices of the newly organized United States Golf Association, took place over the course of the Newport Golf Club, at Newport, R. I.

The very early golf of Scotland was naturally crude compared with the game as we know it, both in its courses, its clubs, and its balls. In those days but few clubs were used, and those almost entirely of wood. Today the average set comprises at least five irons in addition to the driver and brassie. With all the other innovations the ball, naturally was not to be overlooked, although that highly important item in the game did remain unchanged for four hundred years, until at last an

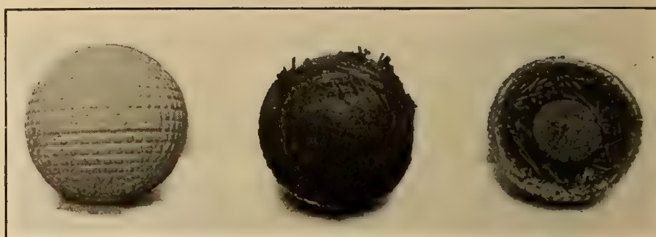


EVOLUTION OF THE GOLF BALL

In the upper row the first two from the left are feather balls, and the second pair early smooth surface gutta percha balls. In the lower row the first two are hand hammered gutta percha balls, the third a filed surface ball, and the last a molded surface ball.

inventive genius evolved something new. Golf in its first four hundred years had been played with a feather ball, with a leather cover; the ball was but little larger than the present type of sphere. The cover was a work of art so far as skill in its hand sewing was concerned. It was not possible in those days to have the highly finished surface of the cricket or baseball as we now use them, nor would it have been quite so beneficial to the game of golf, the seams as then produced being a distinct advantage to the flight of the ball. So many feathers were packed into one of these small balls that it has been said they would more than fill an ordinary hat before they were compressed. It may be readily imagined that such balls might cut or become ill-shaped under the heavy stroke of an iron, hence our forefathers used good common sense in standing to their wooden clubs. Such balls cost, even in those days, when labor was cheap, four shillings each, and of necessity made golf a somewhat expensive game.

About 1850 a new departure came and it was discovered that gutta percha could be molded into the necessary sphere



THE HASKELL BALL, SHOWING THE RUBBER WINDING AND THE GUTTA PERCHA CORE

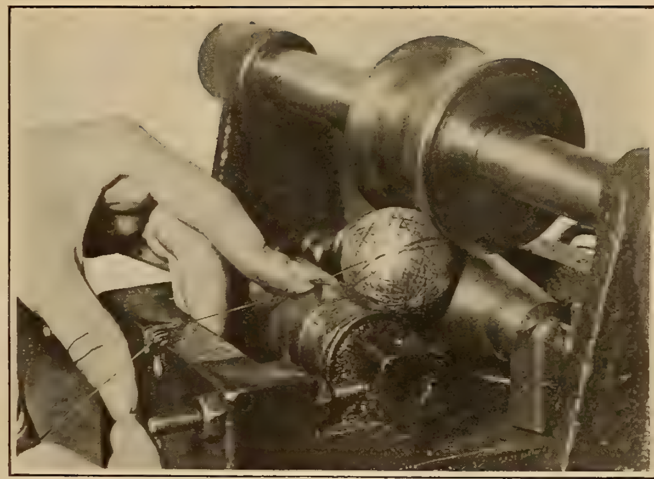
for the game of golf. Among the first Scotchmen to use this new invention was Wm. H. T. Peter. Naturally many experiments were made with this new form of ball. Some balls were made to go farther by increasing their specific gravity with weights in the center; Mr. Peter found that a small portion of lead made the ball more steady.

The introduction of the gutta percha ball tended to make golf a more popular game as the new balls could be made much cheaper than the feather ball; but golf had grown up from, and existed among, a very conservative class, and it was some time before many of the players would experiment with this new ball. Then again the new ball had its tricks, and one had to learn how to handle it; there was a good deal of prejudice against it, and one good opposition was that while it started well off the club it had a tendency to "duck." The reason for this was that the first balls were made smooth, *i.e.*, the seams of the old style ball were missing. Gradually it was found by the more persistent users that after a ball had been played with a few times and received several good bangs, particularly with an iron club, it flew better. As scoring seemed to aid the flight, balls were soon made scored; but the scoring was of a crude nature, being done by hand with a chisel and hammer. These hand-hammered balls continued for some years; in the mean time many men became quite proficient in the art of hammering. With the improved conditions feather balls gradually went off the market, and the cheapened ball soon made the game more popular.

After it had been proved scientifically that the matter of scoring lengthened the "carry" and improved the flight of the ball, scoring became the regular thing and was done by the manufacturers in the molding of the gutta percha at the time the ball was formed. Although it took six months to properly season a good "guttee" ball, it was when matured a very serviceable article, in addition to which it was most distinctly an economical ball, for it could, when well worn, be remolded.

For fifty years the solid gutta percha ball with various forms of marking, from the hand-hammered, the line-marked, and later the bramble-marked, held its own, and it remained for the inventive genius of an American in 1899 to give the golfing world another new type of ball. This new ball, the forerunner of many more of a similar nature, was the result of an evening discussion among a few golf enthusiasts in the famous rubber State of Ohio. Among the party was Mr.

WINDING RUBBER TAPE AROUND THE CORE



WINDING ON THE RUBBER THREAD

Haskell afterward of "Haskell ball" fame. Mr. Haskell decided next morning to try out a scheme which he had had in mind, and immediately set to work on a hand-made ball for experiment. The experiment proved quite an encouraging success when tested out at one of the local golf clubs, and it was not long before the world-famed "Haskell" ball was on the market. The new ball was soon the talk of golfers on both sides of the Atlantic, and so great was the rush among inventors to produce new golf balls that within a year almost a hundred applications for patents on golf balls had been filed in the United States alone.

The original Haskell ball was composed of a gutta percha core encircled by thin rubber thread wound closely about the core, and the two substances enclosed by a gutta percha shell; the core was about 40 per cent of the size of the ball, the remainder consisting of the wound rubber and the shell. For quite a time this continued the general principle of construction in the various new balls, the percentage of composition varying, sometimes consisting of a small core with more winding and more thickness of cover, sometimes a larger core, the tables being turned and the conditions juggled to suit the ideas of the various manufacturers. The world was not allowed to rest for another fifty years without further changes and these more particularly on the inside of the ball. Every new ball brought with it a new form of interior—a ball with a small steel ball inside the center core, hollow cores with liquid centers, a ball with a water-filled core, a pneumatic with compressed air in the core, another with a jelly center to the core—but the india rubber thread and outer shell were still retained. These all took their turn on the market, some suiting the style of one player some another.

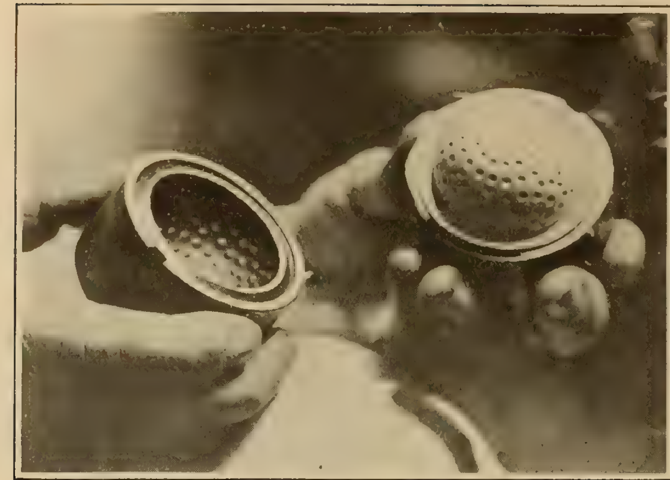
Although we had advanced many years since the days of the introduction of the gutta percha ball, there were still many who were quite prejudicial against this new invention. The first really important test given the Haskell ball was in the Amateur Championship at Atlantic City in 1901. In this championship twenty out of 124 starters in the qualifying round used the new ball, among them Mr. W. J. Travis of international golfing fame, and always among the first to go into a new venture, and Mr. C. B. Macdonald, one of the early amateur champions of this country. Mr. Travis had naturally not acquired proper control of the new sphere, but he managed to win the qualifying medal with it, and turned in a score of 157 strokes, eventually winning the championship in the match play rounds.

It was not long before it was discovered that although the new ball vastly increased the length of a man's stroke, in all shots it was difficult to control on the putting green and it had the same defect which was credited to the early guttee ball—it "ducked." The reason for this latter trouble was that the first balls made were put out with the shallow lines of the "Silvertown" marking. Through the ingenuity of that skilled golfer, James Foulis, who was then professional of the Chicago Golf Club at Wheaton, Ill., this difficulty was overcome. Foulis conceived the idea, thin as the outer shell was, that the new ball with great care could be remodeled; his venture was a success, and he turned out the ball with a "bramble" marking, which was discovered to give the proper flight; the Foulis remade balls were much in demand until the manufacturers themselves put out the ball with bramble markings, which was, if not better, at least more accessible than the limited remades.

The new ball brought with it, even after players had managed to master all its idiosyncrasies, still more troubles. It was not long before courses had to be lengthened to meet the new conditions imposed upon them by the modern ball. Holes

PREPARING THE OUTER SHELLS OF GUTTA PERCHA

FITTING THE SHELL AND CENTER INTO THE MOLD



THE DIMPLE MOLDED BALL, SHOWING THE "COLLAR" THAT HAS TO BE REMOVED BY HAND

APPLYING A COAT OF PAINT BY ROLLING THE BALLS BETWEEN THE PALMS OF THE HANDS

that had been laid out for the average player and bunkered accordingly were made to look ridiculous; irons came into use where drivers and brassies had formerly done the work, so as to shorten up the stroke, and keep the player out of trouble, for several yards were added to the length of every well played stroke, and whereas in former days a 6,000-yard course had been considered a long one, it was now necessary to add four or five hundred yards to keep pace with the times. In the present day we have settled down to more or less of a standard in balls, for this year we are to have limitations as to weight and size in all tournaments; this has been decided by a joint agreement between those two important governing bodies, the United States Golf Association and the Royal and Ancient of Britain. The ball now must not exceed 1.62 ounces in weight nor measure less than 1.62 inches in diameter; the make and style of marking are matters of choice, and in the matter of marking "brambles" which for some years have been the popular fancy, are now giving way to the more modern "dimple" type. There are hundreds who play golf today to whom the gutta percha ball is nothing more than a thing of history.

The manufacturer of the present ball is of course far more intricate than its predecessors; mechanical processes are added to manual skill. The winding of the center core is carefully started by hand, on the centering of this core depend the entire quality of the finished article; for should this be in the least degree at fault the ball would not travel with accuracy. The fine rubber thread is then wound under tension to a predetermined thickness, accordng to the manufacturer's particular style. The outer shells are fitted over the wound ball, and it is submitted to heavy mechanical pressure in the mold to bring the upper and lower shell in perfect union. This contact produces what is called a "collar," which is carefully removed. But there is one stage of the manufacturing process which still remains as it did in the days of gutta percha production; that is the final painting. Modern ingenuity has not yet devised a scheme for coloring that surpasses that of the hand. Hand painting is still the most successful manner of covering the ball with its coat of white paint. But whatever the ball, whether feather, guttee, or of the present style, golf as a game, fortunately, remains much as our ancestors handed it down to us.

PAINTS FOR IRON WHICH IS EXPOSED TO HIGH TEMPERATURES

The following abstract of an article by K. Nicksh is quoted from the February *Journal of the American Ceramic Society:*

"Pure graphite is satisfactory for coatings of furnaces, autoclaves, etc., which are alternately heated and cooled. For good appearance and resistance to very high temperatures sodium silicate has proved efficient. Vessels subjected to even temps. may be protected by a hot application of a mixture of 500 g. of melted lard and 16 g. of powdered camphor with enough pure powdered graphite to give a dark color. The excess which does not penetrate should be scraped off after 24 hours. Cast-iron rust forms a coating which protects the body of the iron from further oxidation. Wrought iron forms no such protective rust but a covering with an iron oxide base, as red ochre, is resistant to acids and fumes at high temps. Walls of furnaces and chimneys where low temps. prevail may be painted with a thin coat of a pitch and tar mixture which has been heated and to which 2 to 3 per cent of milk of lime and a little asphalt has been added. It may be diluted with turpentine. This makes a resistant coating which acquires an excellent luster. *"Durabo"* is a commercial heat-resisting paint which must be preceded by a coat of red lead or iron oxide. Varnishes and drying paints cannot be used, as they crack with temp. changes. Paints should be applied only to perfectly clean surfaces. Previous coats should be removed with 50 per cent carbolic acid solution. Rusted spots should be treated with 5 per cent HCl, followed by a rinsing with a diluted soda solution. After thorough drying the surface should be polished with emery cloth or rotten stone. As base for the paint a thin coat of varnish or linseed oil may be applied.—C. B. Edwards (C. A.)"

THE SOLUBILITY OF METALS IN AMMONIA

While water is the most widespread solvent, holding in solution the greatest variety of both organic and inorganic substances, it has always been held that metals could be dissolved only in other metals. Recent experiments have shown however that hot anhydrous ammonia will dissolve the alkaline metals and some other metals.

First Weyl and then Palmair have succeeded in obtaining solutions whose color differs according to the metals concerned, being blue in the case of the alkaline metals, green in that of lead and red in that of tin, by the electrolysis of organic salts of these metals dissolved in liquid ammonia, which boils at —33.5° C. According to experiments made by Ruff and Geisel 5.87 molecules of ammonia are required to dissolve one atom of sodium.

The study of the electrical conductivity of the blue ammoniacal solution of the alkaline metals has led Kraus to conclude that the metal is dissociated yielding a positive metal ion and a negative electron. Finally, it has been proved by an optical examination that all the metals which are soluble in ammonia, with the possible exception of calcium, yield the same absorption spectrum. The most plausible explanation of this remarkable fact is that the absorption is due to the circumstance that the electrons change their position, carrying with them molecules of the solvent.—From *La Nature* (Paris), for January 1, 1921.

The Ballistic Wind*

French Studies of the Effect of Wind Pressure on Projectiles in Flight

By J. Rouch

Naval Lieutenant, Former Chief of the Meteorological Service of the French Army and Navy

It may be said without fear of contradiction that before the war the influence of meteorological factors by no means occupied a place in accordance with their importance in the calculation of the flight of projectiles. In those days it was thought sufficient to make measurement (and without any great degree of precision at that) of the temperature, and the direction and velocity of the wind in the vicinity of the batteries. The tables employed did not permit of an approximation at all close of the effect exerted by these factors upon the projectile. The sights were set by trial ranging and little attention was paid to the number of shots fired before the correct aim was found.

The navies, however, have long made a more extensive study of the problem of securing a rapid adjustment of the aim—the quantity of projectiles which it is possible to store upon shipboard, is, of course, very limited and it is important not to waste them; furthermore, in naval battles the man at the gun is not only a marksman but a target, and victory perches upon the banners of those who first hit the mark.

The great development during the war of the use of heavy artillery at the front, led to a similar study of rapid aim on the part of land batteries—the available amount of projectiles was more or less limited and furthermore, the work of air scouts was of great aid in locating the enemy's batteries. It accordingly became necessary to shorten the regulation time and to make the first projectile come as near the mark as possible. This has a double advantage since it makes the work of the scouts easier when the projectiles fall sufficiently near the target to be immediately located. Observation of these matters led to the initial elements of the aim whose study had been somewhat neglected to be regarded with the importance they deserve. Furthermore, the arrival of marine gunners at the front contributed to the increasing application of exact methods of aiming.

In order to make a precise calculation of the initial factors concerned in a good aim, it is particularly necessary to have a knowledge of the influence of the wind. But the exact character of this influence was not then thoroughly fully understood. The range tables habitually employed, even by marine gunners, did not give the corrections required in the function of the wind except in the neighborhood of the ground and entirely failed to indicate the variations of the wind due to altitude. It was not until 1915 that a discussion of the sighting done by various groups of 19's, especially of the 1st and 3rd groups, led to the discovery of the simple and almost intuitive rule which appeared to be sufficiently exact for all practical purposes, that the deviation imparted to the projectile by the wind is proportional to the time during which the projectile is subjected to the said influence.

The application of this rule to the regulation of aiming during a fight or "sighting" was made for the first time at the battle of Artois May 9, 1915, by the first group of 19's. To calculate the influence of the wind it is necessary, therefore, to know the variations of the wind at different altitudes, and to obtain this information sounding balloons must be sent up from stations located near the batteries. It will be remembered that the velocity of the wind at different heights is measured by following the drift of a small balloon with a theodolite. This operation is termed an aerological sounding, but until 1916 only a few of such sounding stations existed, and it was scarcely possible, therefore, to make much improvement in sighting methods because of the lack of sufficient data with regard to the wind. A decisive impulse was given to the latter by Marshal Foch, who was then in command of the armies of the North; in the instructions which I received from him to organize the meteorological service in preparation for the battle of the Somme, the information to be furnished to the artillery was held to be as important as the general weather forecast provided for the air force or the gas companies. During the entire battle of the Somme in 1916 we made it our endeavor to improve the meteorological information designed to assist the artillery and along the battle front the sounding stations newly installed made about twenty aerological soundings per day from June to October. These experimental tests induced the general in command to give orders in October, 1916, to make a general application along the entire front of the methods employed during the battle of the Somme. This was precisely stipulated in the orders sent to the meteorological service October 22, 1916.

But at that time we still adhered in our calculations with regard to the influence of the wind to the rule established by the groups of 19's. Upon the receipt of the reports from the sounding station it was the duty of each battery to calculate the effect of the wind upon the projectile in each stratum of air given, and then to summarize these partial results in order to obtain a total correction. Such an amount of calculation inevitably required a good deal of time, and it was frequently impossible to make it because the length of the portion of the projectiles trajectory in a successive strata of the atmosphere was not known. In such cases the wind which prevailed was taken at two-thirds or three-quarters of the rise of the trajectory without any very adequate reason, and then entered this wind in the tables of correction.

In order to make general the employment of precise directions, it was necessary to discover a rule which should be simple and easy to apply. Making any sort of calculations under the fire of the enemy always seems a rather complicated matter and a man in the thick of the fight finds it a bit difficult to compose his mind to calm scientific observations. The problem was solved by means of a note by Major Taton, commanding the 7th Groups of 32's and by a very complete study of the duration of the trajectory of projectiles in the atmosphere, which was made in January, 1917, by MM. Lebesgue and Montel, members of the mathematical service of the Bureau of Inventions.

Major Taton drew attention to the fact that in the case of projectiles of the 32's, no matter what the charges employed, the durations of the trajectory of the projectiles in the various strata of the atmosphere were practically the same as those obtained by observations of trajectories in a vacuum. MM. Lebesgue and Montel demonstrated that the comparative duration of the trajectory in the successive strata of air were independent both of the caliber of the guns and of the initial velocity and that they depended only upon the rise of the trajectory.

Two projectiles which ascend to the same altitude remain in a given stratum of air during the same fraction of the duration of the total trajectory. It is permissible, therefore, to replace all the variable winds which exert an effect upon the projectile, by a fictitious constant wind which is the same for all projectiles whose trajectory has the same rise. The calculation of a fictitious wind can be made by an entirely different service, *e.g.*, by the meteorological service in charge of wind observations instead of by the artillery.

THE BALLISTIC WIND

It was on February 10, 1917, that we sent to our armies a first note with respect to the calculation of this fictitious

*Translated for the *Scientific American Monthly* from *La Nature* (Paris), July 24, 1920.

wind, to which was applied the term *ballistic wind*. The ballistic wind was calculated as follows:

Let T represent the duration of the total trajectory of the projectile and small t the length of time during which the projectile remains in a given atmosphere of stratum. If we assume that the effect of the wind upon the projectile is proportional to the time during which it operates, then in each layer of the atmosphere the effect exerted would be proportional to the ratio of t/T.

But the factors t/T can readily be calculated in function of the arc or rise of the trajectory since they are the same as for a trajectory *in vacuo*, and these factors are the coefficients which will affect the values of the wind in the successive layers of air.

For example, in the case of a rise of 2,000 m. it would be necessary to multiply the winds observed from 0 to 500 m. by 0.13, those from 500 to 1,000 m. by 0.16, those from 1,000 to 1,500 m. by 0.21, and those from 1,500 to 2,000 m. by 0.50. The geometric sum of these different winds would be the ballistic wind corresponding to all those projectiles having a trajectory with a rise of 2,000 m.

By means of tables very rapid calculations can be made at meteorological stations to determine the ballistic winds corresponding to each rise of 500 m.

The employment of the ballistic wind rapidly came into general use among our armies and this easy correction process met with great favor from most of our batteries. The practical results were found to be excellent as was proved by the very large number of letters from commanders of batteries or groups. I will here content myself with a citation from one written to me by Lieut.-Colonel Gay, commander of the R.C.A.L. Group of the 6th Army on May 18, 1917, following the battles which took place in April:

"The ballistic wind transmitted by the meteorological station or by the sounding stations of the army has been employed in making preparation for the firing of heavy artillery, for the values of the rise of the trajectory comprised in general between 1,500 and 3,000 meters and which have sometimes exceeded 6,000 meters. The precision attained was as follows:

"1. For long guns firing with a rise of approximately 2,000 m.—first salvo generally at less than 100 m. from the mark—it was especially noted that photographs revealed that certain shots by 32's which had to be made without observation because of the prevailing fog, exactly tallied.

"2. Howitzers and mortars of large caliber (rise from 3,000 to 5,000 meters) were found equally exact.

"3. For long guns with very great range (rise from 5,000 to 6,000 m.) the initial deviation was about 200 m. for a total correction of approximately 1,000 m. These results are most excellent, hence the present process of employing the ballistic wind renders the best of service."

Numerous testimonials of the same sort confirm the importance of this new method, and at the beginning of 1918 the Bureau of Marine Service upon the receipt of a letter from a general in chief, summed up these testimonials in the statement that "an extremely important contribution has been made to the attainment of precision of aim in the French armies." An equally prized testimonial came to use in a letter from M. Borel, at that time director of the Scientific Service of the Bureau of War, who congratulated us upon having accomplished this important reform so rapidly.

However the ballistic wind found some critics. The ballistic rule which served as the basis was criticised in these words: "The effect of the wind is *not* proportional to the time during which it acts. The preponderant action is not necessarily the action of the wind at high altitude but may possibly be that of the wind at low altitude."

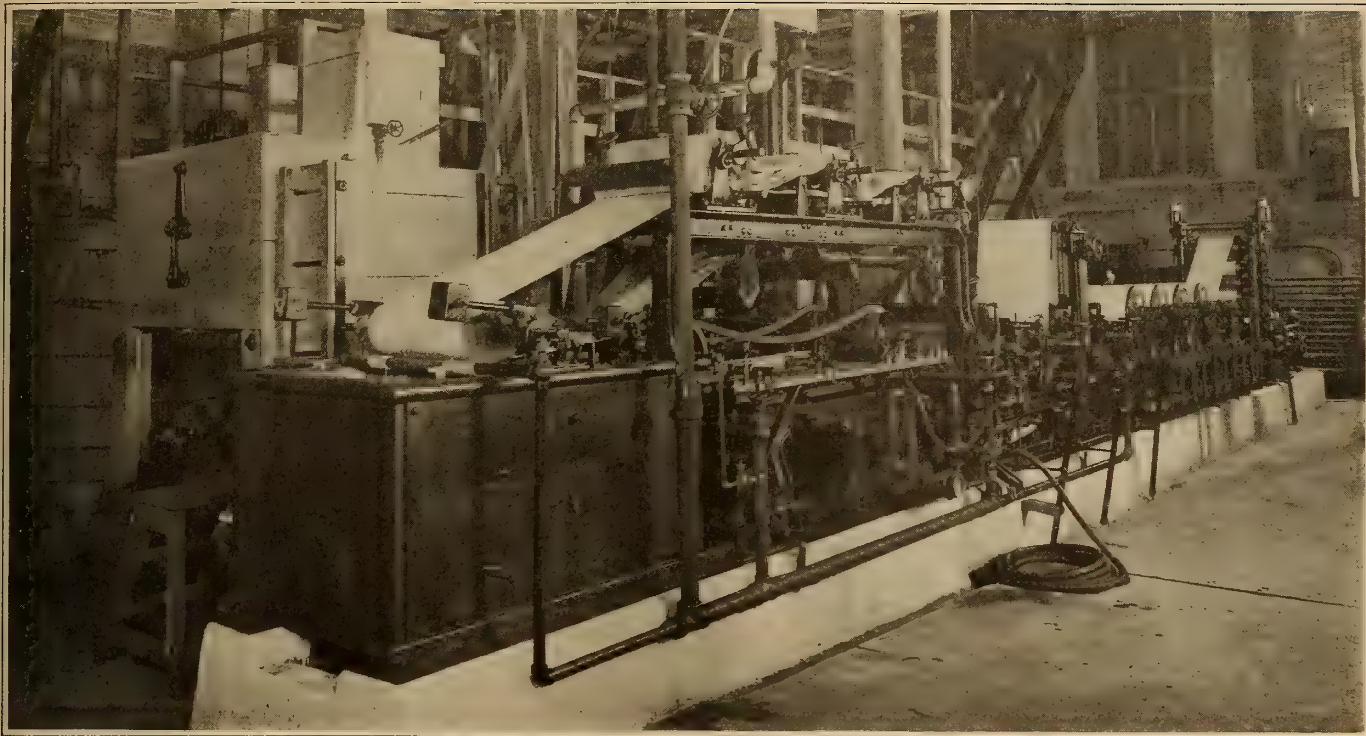
The laborious studies of the commissions upon taking aim in the endeavor to decide the problem did not arrive at the establishment of simple rules until after the end of the war. The intuitive law accepted by the groups of 19's in 1915, continued to be adopted by the great majority of batteries, since it was found that this law permitted the making of marvelously accurate shots. Thanks in part to the ballistic wind, precision of sighting made great progress in the course of a single year, not only in the heavy artillery but also in the light artillery.

We do not mean by this that the present methods for determining the correction of the wind are incapable of being improved. Moreover it does not lie within the province of meteorology to solve this problem of ballistics. The problem solved by the meteorological service may be stated as follows: A law of ballistics being given how can a fictitious wind be calculated which can readily be transmitted to the batteries and applied by them. The actual progress attained consisted in solving this question. Without the ballistic wind there would always have been certain battery commandants, who would have felt constrained to make long calculations to discover the corrections of the wind; but this degree of precision would have been attained only by a minority, whereas when the artillery was furnished with a fictitious wind already calculated it was applied by all the batteries and the general precision of sighting was thus considerably increased. If in the future some other law of ballistics should be discovered, it would be necessary to attempt to state the said law in such a form that the meteorological service, which measures the wind, will still be able to calculate the fictitious wind to be applied by the artillery.

DISPERSION OF PROJECTILES

Investigations recently carried on as to the dispersion of projectiles, including experiments at Aberdeen Proving Ground, Md., have shown that the dispersion of field high explosive projectiles ranging in caliber from 75-mm. to 8-in., is mainly due to the behavior of the projectile in the part of the trajectory near the gun. It had previously been shown that as the projectile leaves the gun it executes a series of periodic swings similar to the swing of a clock pendulum; the plane in which the swing occurs rotates uniformly; amplitude of the swing in the case of some service projectiles is as great as eight degrees on either side of the trajectory, but it varies considerably from round to round. As the projectile reaches greater distances from the gun, the character of the motion changes from that of swinging back and forth across the trajectory to a type of motion in which the projectile swings or precesses around the trajectory; amplitude of motion decreases until about a mile from a 75-mm. gun the projectile is traveling almost nose on. Resistance of such a swinging projectile is considerably greater than that of one traveling nose on, depending on amplitude of the swing. Consequently a projectile having a large swing near the gun will lose more velocity and have a shorter range. The dispersion, especially at high elevations of the gun, is due mainly to this effect.

In the light of this, the general problem of designing accurate projectiles depends upon three factors: Effect of design of the projectile and twist of rifling upon amplitude of initial swing; effect of shape of projectile on increase of resistance caused by the swinging motion; rate at which the swing dies out as depending on design of the projectile. Considerable progress has already been made in investigation of the first and third factors, and a new chronograph is being installed at Aberdeen for investigations with regard to the second factor, *i.e.*, increase in resistance due to the swinging motion. It has been possible to make comparatively accurate predictions of the relative dispersion of the same design of projectile when fired in guns of different twists of rifling. It is expected that when investigations now under way have been extended, it will be possible to predict approximately the amount of dispersion of a given type of projectile in a given gun before it has been fired. For example, if it were desired to design a projectile and rifling for a 100-mile gun, it should be possible to predict what proportion of the shots would land within a two-mile circle a hundred miles away from the gun.—Abstracted by *The Technical Review* from *Army and Navy Journal*, Feb. 5, 1921.



EXPERIMENTAL PAPER MACHINE AT THE FOREST PRODUCTS LABORATORY

This small machine is equipped with both Fourdrinier and cylinder wet ends and is used in making paper from the experimental pulps cooked at the laboratory.

Book Paper from Southern Woods

Possibility of Using Pines and Other Conifers to Furnish a Perpetual Supply of Pulp

By Sidney D. Wells *

THE paper shortage during the past five years has been such that the individual who has not been brought to feel its existence is indeed rare. A great variety of reasons have been given and remedies suggested, and while many of the latter may have a measure of merit, the situation can only be relieved by attacking it from many sides—single or isolated efforts will not suffice. Shortage of wood was the reason most commonly given for the situation; but while some shortage undoubtedly existed a glance at the figures of standing timber, even in the older sections of the country shows that the consumption of wood for wood pulp is but a small fraction of the wood available, and the prices paid for it are much in excess of those paid for wood for other purposes. Why then does the reported shortage exist? A brief outline of the amounts of pulp made in the United States by each of the important processes and the wood requirements will serve to explain. The figures for the year 1918 are taken since no later figures are available.

In manufacturing 1,303,000 tons of mechanical pulp 1,345,000 cords of wood were consumed. The mechanical process usually requires the best quality of pulp wood, since the color and cleanliness of the pulp reflects directly the condition of the wood; for this reason over 85 per cent of the wood used was spruce. Six per cent was made of fir, 4 per cent Western hemlock, and 5 per cent of all other species.

In manufacturing 1,386,000 tons of sulphite pulp, 2,860,000 cords of wood were required. Seventy per cent of this was spruce and fir, 26 per cent hemlock, 2 per cent poplar, and 2 per cent all other species. The sulphite process is not quite so rigid in wood requirements, but manufacturers are not yet using appreciable amounts of resinous woods.

*Engineer in Forest Products, U. S. Forest Service, Forest Products Laboratory, Madison, Wisconsin.

In manufacturing 344,000 tons of soda pulp 749,000 cords of pulp wood were required. Any wood may be reduced to pulp by the soda process, but the strength of the paper produced is not so great as might be possible using the sulphate process. Consequently, the soda process is used mainly in the production of soft, easily-bleached, short fibered pulps for uses such as book paper where strength is not so important as proper printing qualities. In this process 80 per cent of the wood used was from deciduous trees.

In producing 167,000 tons of sulphate pulp 296,000 cords of wood were used. The sulphate process which is a modification of the soda process, is alkaline in nature and uses similar equipment.

Any species of wood can be reduced to pulp by this process, but because this process is specially adapted to the production of strong pulps, only long fibered coniferous woods are used. The presence of resinous matter in the wood offers no difficulties, and knots and bark are often digested with the wood with satisfactory results. A larger proportion of saw mill waste is used in this process than in any other. The process has only recently been introduced in the United States, and the tonnage at present is comparatively small but it is growing more rapidly than any other.

From the above description it is apparent that of the 3,200,000 tons of pulp annually produced in the United States 2,690,000 tons or 84 per cent is dependent on very few species of wood which belong to the spruce, fir and hemlock families. These species comprise only 11 per cent of the standing timber, as compared with 60 per cent of the standing timber among the pines, Douglas fir, cypress, redwood, larches, and cedars, and 29 per cent among the deciduous species. Table I gives the geographical distribution of species and also shows that the coniferous regions where the pines predominate have by far

the greatest annual growth, which indicates the possibility of a perpetual supply of pulpwood where these conifers can be used.

In considering the possibility of utilizing the pines and other conifers not now used for paper products, the annual production of the different classes is of interest and is given below for 1918:

Paper board	1,927,000	Tons
Newsprint	1,260,000	"
Book paper	849,000	"
Fine paper	368,000	"
Wrapping paper	714,000	"
Bag paper	177,000	"
Felts and building	284,000	"
Other grades	471,000	"

In the above classes of paper unbleached sulphate from the pines and other conifers could be used to advantage in wrapping and bag papers, and as the strengthening fiber to give the necessary strength to the old paper stock which forms the bulk of the raw material in the paper board class.

TABLE I

Geographical Distribution of Species[1]

	New England	Middle Atlantic	Lake	Central	S. Atlantic and East Gulf	Lower Mississippi	Rocky Mts.	Pacific Coast	Total
	%	%	%	%	%	%	%	%	%
Spruce hemlocks and firs	1	1	1	....	....	....	1½	6½	11
Pines	1	1	1	⅓	7½	7½	4½	7½	30½
Douglas fir	....	....	....	....	....	....	1	19	20
Cypress and Redwood	....	....	....	....	½	½	....	2½	3½
Tamarack and cedars	½	½	1	½	....	....	1	3	6½
Hardwoods	½	1	4	10½	5	7½	....	....	28½
Total	3	3½	7	11½	13	15½	8	38½	100
Annual growth	8	8	7	5	27	16	6	12	100

Newsprint, however, depends on mechanical pulp and sulphite for its raw material, and book paper depends very largely on sulphite pulp, soda pulp, and reclaimed magazine stock.

In order to find a cheaper raw material for the manufacture of book paper, with the assurance of a perpetual supply, the use of the Southern pines has often been suggested. So far as the writer knows, however, attempts to accomplish this result have met with failure. Recently, experiments were carried on at the Forest Products Laboratory to determine the possibilities of loblolly pine as typical of the Southern pines together with red gum as a source of bleached pulp for book paper. The results were successful. In this work, the sulphate process was used and was found to give pulps that bleached with reasonable amounts of bleaching powder with higher yields per cord of wood than is obtained from spruce or poplar. The sulphate process is commonly regarded as specially adapted to the production of unbleached pulps but the work referred to indicated that it is far superior to the soda process in the production of bleached pulps from either coniferous or deciduous trees, and with some woods a satisfactory degree of white can be obtained that is impossible with either the soda or sulphite processes. In the manufacture of book paper it is customary to mix a long-fibered stock such as spruce sulphite with a short fibered but soft stock, such as bleached poplar soda pulp, in proper proportions to obtain the necessary strength combined with the proper printing qualities. The strength is obtained from the long fibers of the sulphite pulp while the proper degree of softness, bulk, finish, opacity, etc., is obtained from the soda pulp. All the properties mentioned were obtained by using loblolly pine and red gum in equal proportions, and pulping by the sulphate process.

In this process the wood is chipped in the usual pulp wood chipper to a size of from ⅝ to ¾ inch with the grain and then screened and conveyed to large bins above the digester. The digesters are cylindrical wrought iron or mild steel vessels with conical bottoms, and they are capable of holding from five to fifteen cords of wood in chip form. The chips are run into the digesters with the cooking liquor which consists of a solution of caustic soda and sodium sulphide, the active reagents, and a certain amount of inert chemicals such as sodium sulphate and sodium carbonate caused by the incompleteness of the smelting and causticizing operations, which will be mentioned later. After charging, the digester is sealed and heated by either blowing in high-pressure steam, or by circulating the liquor through a heater on its way from the bottom to the top of the digester. After digestion, which takes from three to six hours at 90 to 120 pounds pressure, the contents of the digester are blown into a cyclone separator and dumped into a wash tank, or blown into one of a series of closed wash tanks called diffusers; and the pulp is washed with water. The spent cooking liquor, called black liquor on account of its color, contains the soda combined with from 55 to 60 per cent of the wood substance. The pulp is run over suitable machines to remove the water used in washing it from the diffusers and is ready for the bleaching operation, or shipment as unbleached pulp. The black liquor is concentrated in multiple effect evaporators, flue gas evaporators, and rotary incinerators from which it immerges as a mass resembling tarry coke. It is then fed into smelters together with sufficient salt cake (crude sodium sulphate) to make up the loss of soda in the recovery cycle. In the smelters, the remaining carbon derived from the wood substance in the black liquor is burned at a very high temperature by means of air nozzles, and the soda compounds in the black liquor are converted to sodium carbonate, while the sodium sulphate is reduced to sodium sulphide. These compounds run from the smelters in a molten condition into dissolving tanks, and, when the solution has the desired strength, it is pumped to the causticizing department where the sodium carbonate is converted to caustic soda by means of quick lime, and the sodium sulphide remains unaltered. The solution of caustic soda and sodium sulphide obtained is diluted to the desired strength and used in cooking the chips as already described.

The caustic soda has a very drastic action in resolving the ligneous and resinous constituents of the wood to soluble compounds and a certain portion of the cellulose (of which the pulp is almost entirely composed) is dissolved with correspondingly lower yields. The sodium sulphide has a similar action on the ligneous matter, only it is about half as drastic. Its strong reducing action furthermore serves to protect the cellulose while the compounds that produce the color in the unbleached pulp, though they exist in extremely small quantities, are rendered more susceptible to the action of bleaching agents.

In digesting wood for pulp which is intended to be bleached, more drastic cooking conditions are used than when pulp is desired that will be used unbleached. The yield of the latter is usually from 42 to 45 per cent of the dry weight of chips used, while the yield of bleaching pulp is usually not over 40 per cent, and, in the case of sulphate pulps from coniferous woods, as low as 36 per cent. In order to bring about the removal of coloring matter, known to be less than 2 per cent of the weight of the pulp, and probably much less, a reduction in the amount of pulp obtained of over 10 per cent based on the weight of the pulp is necessary when using these methods.

[1]Table I was compiled from data and information given in Report on Senate Resolution 311, "Timber Depletion, Lumber Prices, Lumber Exports, and Concentration of Timber Ownership" by the Forest Service, U. S. Department of Agriculture, and "The Lumber Industry" by the Bureau of Corporations, U. S. Department of Commerce and Labor.

DRY PULP TAKEN FROM PRESS

The pulp is pressed after removal from the blowpit. The pressed cakes are much easier to handle

PULP BEATER AT THE FOREST PRODUCTS LABORATORY

Experimental pulp made from waste cotton hull fiber is being mixed with water preparatory to running it into paper.

The waste and costliness of these drastic methods of attaining the results desired were recognized in the experiments under discussion and efforts were made to modify the bleaching treatment whereby yields of pulp as high as 42 per cent could be bleached. It was finally found possible to obtain these results by dividing the bleaching treatment into two steps. From one-third to two-thirds of the bleaching liquor, which consisted of a solution of common "chloride of lime," was added and the pulp circulated for about two hours when the chlorine, the active chemical, was found to be exhausted. The pulp was then washed and the remainder of the bleach added. It was found that the above procedure made possible the bleaching of pulps with yields of pulp as high as 42 per cent with bleach consumptions of from 15 to 20 per cent, while bleaching the same pulps in the customary manner required from 30 to 40 per cent. It is usually considered not feasible to use more than from 20 to 25 per cent of bleaching powder to bleach wood-pulp; and when more is required, the cooking conditions are made more drastic and the yield decreased until the customary bleaching requirements are met. Yields of only 35 per cent would be obtained in producing pulps that could be bleached between 15 and 20 per cent in the customary manner. It is, therefore, apparent that by means of the modified bleaching method the yield of pulp obtainable has been increased over 16 per cent. The method is furthermore one that can be readily adapted to modern bleaching equipment and would not increase the cost of bleaching greater than the overhead, maintenance and power costs entailed by an increase of 50 to 100 per cent in the bleaching equipment. Inasmuch as the strength and color of the pulps obtained are considerably improved, the higher cost would be taken care of by the better quality of the product. The output of the pulp mill would also be considerably increased because not only was the output per digester charge increased 16 per cent, but the time of cooking and amount of cooking chemical required per digester charge was reduced by 16 per cent. In other words, a mill capable of producing 50 tons of pulp per day using the customary method could increase its output to 70 tons per day by using the modified bleaching method, and altering the cooking conditions accordingly.

It has been pointed out above that by the use of proper cooking and bleaching methods economically feasible loblolly pine and red gum can be used as a source of bleached pulp for the manufacture of book paper. Work on most of the other Southern pines, black and tupelo gum, swamp maple and similar woods occurring in sections of the South unsuited for agriculture indicate that they all are substantially as well adapted for the purpose. The prevailing prices of cord wood and mill waste throughout the South would indicate a source of raw material at less than half the cost experienced in the present pulp making centers; and the supplies of spruce, fir, balsam, hemlock, and poplar are rapidly disappearing. Many localities in the midst of plentiful supplies of wood are also favorably located for shipping facilities, in proximity to supplies of coal, lime, salt cake, and other supplies, and there is no reason why the manufacture of bleached pulp and book paper cannot be made profitable provided efficient organizations can be effected. The climate, the fact that the industry would be entirely new to the locality and entail the necessity of employing skilled help accustomed to different environments, and the use of unskilled help unaccustomed to industrial environments are serious obstacles, but notable examples of the successful establishment of other industries indicate large possibilities.

DISCOLORATION OF METAL

The *Houghton Industrial Digest* for February discusses sunlight as the cause of discoloration of polished metal parts. An inquirer states that three years ago a new mill was erected and equipped with expensive machinery and special pride was taken in keeping bright parts polished and free from rust. They were polished with waste and rubbed with lubricant oil, but after a time took on a brownish color which, while it did not resemble rust, could not be removed. Examination of the machinery showed that most of the discoloration was to be found upon metal parts exposed directly to the light and where direct rays of the sun could strike the metal, the spots were darkest. Bright parts in semi or complete darkness were unaffected and the conclusion is inevitable that the brown coloration in question is due to the action of the sunlight on the lubricant oils used in the effort to prevent rust. It is probable that the action of light upon these hydrocarbons caused a deposition of carbon and a great liberation of carbon. It is also well-known that various metals have affinity for carbon so that if the hydrocarbon is affected by the light the carbon deposits in the pores of the metal give a brownish stain.

GENERAL VIEW OF ANCIENT OSTIA AND THE TIBER, SHOWING RUINS OF WAREHOUSES

A New Port for Rome

The Ancient Harbors of Ostia and Porto on the Tiber

By Albert A. Hopkins

Fellow of the American Geographical Society

THE economic depression resulting from the World War has directed attention to the utilization of forgotten resources. We look to gain wealth from waterfalls and rapids, we try new foods and intensive cultivation, so it is not surprising to find Italy alert to save every lira by reclaiming her barren land and promoting housing in new localities.

Prince Orsini, of the famous Roman family, has succeeded in interesting capital in a scheme of land reclamation of the *Agrum Romanum*—an immense barren tract between Rome and the Mediterranean. This country was once of great fertility and was dotted with castles and villages but they fell a prey to marauders, Saracens and pirates, and then to the more deadly foe, malaria; for the region includes the famous Pontine Marshes. It is a mistake to consider this land as a dreary extent of stagnant, slimy water, traversed by melancholy roads; on the contrary the marshes resemble the rich plains of Lombardy with abundant grass and herbage which grow with a luxuriance which Italy of the North can never exhibit. No roads could be more excellent than those which lead through the marshes, upon which the carriage or automobile rolls along between unending alleys of trees whose thick branches afford a welcome shade from the scorching sun. Canals cross one another and drain off some of the water. Occasionally a solitary post house is passed which shows the effects of the poisonous effluvia which steam up from the marshes. The lime-washed walls are entirely covered with an unctuous gray-green mold. This stamp of corruption follows human beings as well and the peasants are pale yellow and sickly in the extreme.

It is now proposed to remedy all this, for the marshes can be drained and the country made one of the most healthful parts of Italy. This reclamation work will occupy six years and will cost $50,000,000—a large sum for Italy to invest at this juncture, but English and American banks have looked with favor on the project. Once the dread malaria is extirpated, this land would be of inestimable value to Rome and would make the city self-supporting and bring back to the capital of the Cæsars something of its old time glory.

The chief town in the area is Ostia, which, in 50 B. C., was one of the principal cities of Italy, but in the first century it was ruined by the silting up of the port and without modern dredges the case was hopeless. The Emperor Claudius built a new harbor up the Tiber two miles above Ostia; this silted up in a time and the Emperor Trajan built another harbor in A. D. 103 united with the port of Claudius on the west and with the Tiber by a canal. In the 10th century this port became filled up and commerce went to mediaeval Ostia and in 1612 the canal of Trajan was once more cleared out by Pope Paul V. and connected with Fiumicino. Since then this has been the only way by which vessels can ascend the Tiber, the other branch having been almost entirely closed up by sand near its mouth. It is now proposed to build another city near Ostia to relieve the housing situation in Rome, the distance being less than twenty miles. This would give Rome a maritime port which she needs badly, Civita Vecchia being altogether too far away. The engineering charges would be borne in connection with the reclamation work on the marshes.

It would perhaps be worth the reader's while to glance briefly at a short sketch of Ostia, "Porto" as the Claudian-Trajan port is called, and also Porto d' Anzio the ancient *Antium* which was of great commercial and military importance to Rome. It should be noted that this seaport is not on the Tiber but is in the other direction about as far to the south of Ostia as Civita Vecchia is to the north.

The subject of the trade of Rome is an interesting and important one. The metropolis of the ancient world at one time numbered about 1,000,000 inhabitants, and it was no small task to provision this city. Ostia, on the coast of the Mediterranean Sea, now about twenty-one miles by rail from Rome, was naturally the great *entrepôt*. It was settled in the second century after the foundation of Rome, by Ancus

Martius, and soon became an important commercial town. Under Augustus it lost some of its importance, due to the choking up of the harbor by the Tiber. Christianity was introduced at an early date, and the Bishopric of Ostia, according to some accounts, was founded by the apostles themselves. The early Popes were all consecrated by the Bishop of Ostia.

The Tiber at present washes down eight and one-half million tons of sand annually, and this gradual extension of the delta has left Ostia miles inland. The astronomer, Padre Secchi, and Professor Lanciani have determined that the average yearly advance of the coast is about 19 feet.

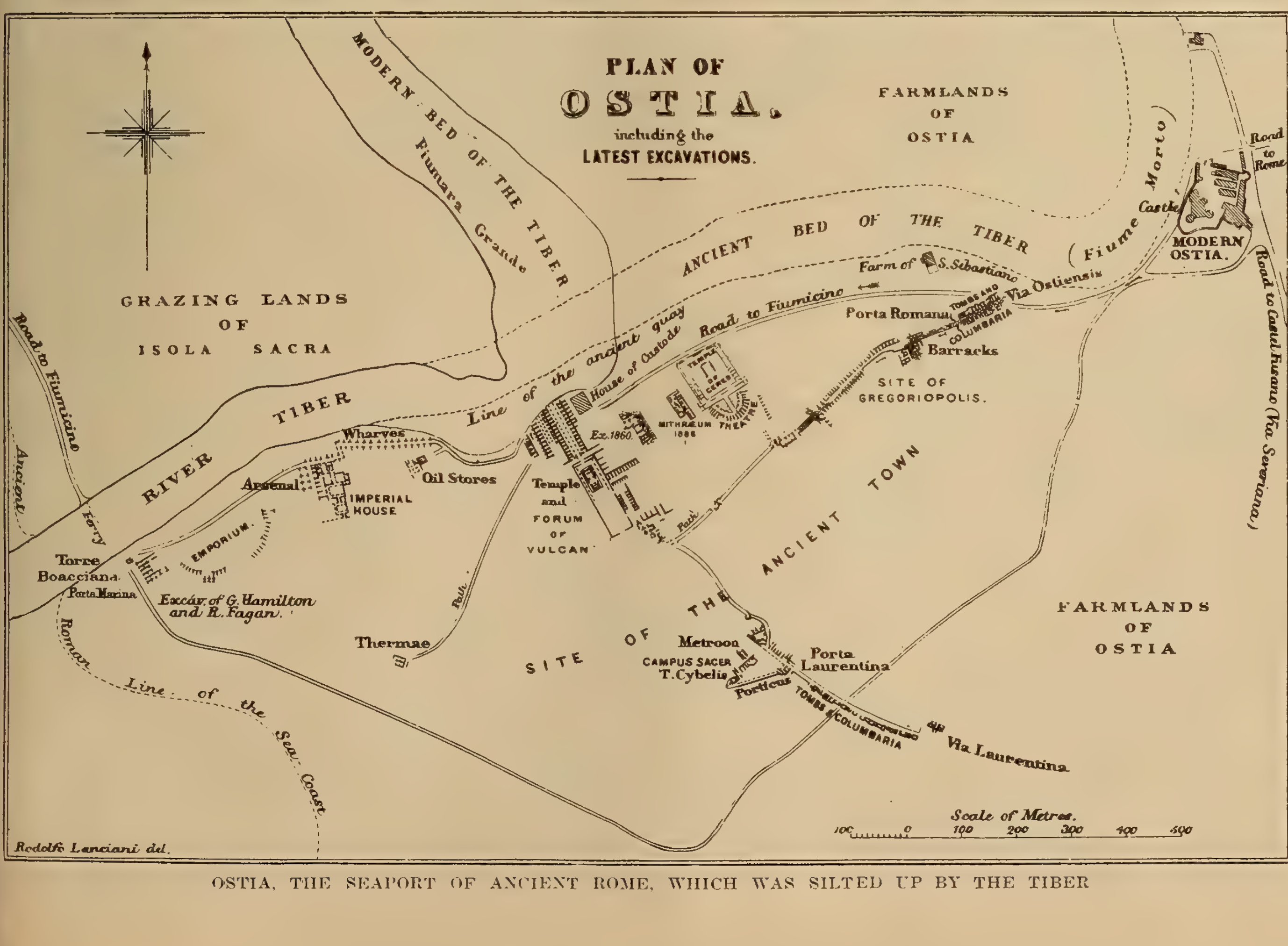
The Tiber was a bad river to navigate, and while an ancient man-of-war could easily get over the bar, owing to its light draught and great propelling power, merchantmen usually had to anchor outside and discharge their cargoes with the aid of lighters. The old Romans made no attempt to improve the harbor, which they could have done very easily, for vessels of 150 tons burden now reach Rome. In early times the vessels were towed upstream by oxen and buffaloes, tow-paths being provided for them. Navigation was not allowed at night and the vessels had to moor at stations. Professor Lanciani states that there were thirty of these stations between Rome and the sea. Vessels from Ostia often reached Alexandria in eleven days and Gibraltar in five days.

At Ostia the warehouses covered one-half of the town, which was two miles long and one mile wide. The city of Ostia must have presented a splendid appearance, as it contained fine temples, theaters, and villas of patricians, and the ruins were so extensive that for five centuries the villagers burned marble for lime without exhausting the supply; and when Poggio Bracciolini visited Ostia with Cosimo de' Medici they found the villagers occupied with burning an entire temple into lime. It is sad to contemplate the loss of so many antiquities, for the rude peasants burned wall facings and statues alike.

Our engraving represents the warehouses along the so-called "Street of Wharfs." The floors are raised three feet above the pavement to facilitate the loading of carts. On the opposite side the ruins seem to belong to the private houses of merchants, the ground floors and basements being used for storage purposes. One of the rooms is in excellent preservation. It is 36 feet long by 28 feet wide, with six rows of large earthen oil jars 4 feet in diameter, each marked with its capacity. Another store belonging to the same house is vaulted over and has two circular openings for light. The barrack of the firemen (vigles) and constables is one of the important ruins of Ostia. These men were numerous, as frays and fires are very apt to occur where large bodies of lawless sailors are congregated.

One of our engravings shows a portion of one of the warehouses, and it may also be seen in the middle of another of the engravings. It gives an admirable idea of the solidity with which the Romans built all constructions of this kind. Through the arch to the left may be seen the concrete which was faced with what is known as "*opus recticulatum*," where the stones were carefully cut so as to present a square or lozenge-shaped end, and are fitted very closely one to the other. These little blocks are about 3 inches square and are arranged to run in diagonal lines; the angles of the wall have neatly worked quoins with the inner end pointed so as to work in with the small lozenges. The effect of this sort of facing is very neat, but its beauty seems to have been very largely concealed by stucco. The front walls of the warehouse were built of brick which average 1 foot 11 inches square. The voussoirs are also of brick and the pediment and entablature are admirably handled. The engraving is interesting as showing Roman methods of construction, and also as showing how well the Romans built, even where the structures were used for such ordinary purposes as warehouses.

The harbor which Claudius built two miles up the coast from Ostia was inclosed by jetties. The area of the harbor was about 6,200,000 square feet, and the quays were over a



OSTIA, THE SEAPORT OF ANCIENT ROME, WHICH WAS SILTED UP BY THE TIBER

DOOR OF A MAGAZINE ON THE PRINCIPAL STREET OF OSTIA

INTERIOR OF WAREHOUSE WITH BURIED AMPHORA FOR OIL, WINE, ETC.

mile long. The breakwater was constructed with the aid of caissons. The huge ship by which the Vatican obelisk was brought from Egypt was filled with concrete until it sank, then it was strengthened with rocks until it was above the level of the sea, when it was crowned by a lighthouse.

"Porto," Trajan's harbor, is now two miles inland, and is a shallow lake surrounded by ruins. It resembled in every way a modern port: it was hexagonal in shape, and the basin communicated with the Port of Claudius. Trajan's harbor is one of the most interesting works of Imperial Rome.

Egypt alone shipped 190,000,000 bushels of grain to Rome, and Sicily, Sardinia, and other places poured in their enormous supplies of foodstuffs. In addition to this may be reckoned the vast quantities of building materials, especially marble, which were imported. The Claudian Harbor was also used as a great naval station, and here was also the central post office for foreign correspondence. In modern times harbors have been constructed on even a larger scale than the three harbors mentioned, which successively served to receive the great ocean-borne commerce of Rome, but none of them ever possessed the same magnificence.

We quote from Rodolfo Lanciani's "Ancient Rome in the Light of Recent Discoveries,"[1] as follows:

"The Claudian harbor was not only a commercial, but also a military station, from which emperors and admirals were wont to sail, escorted by powerful fleets on their expeditions to the far-away border lands of the empire. The same harbor contained a central post office for correspondence with the provinces beyond the sea, the existence of which office was revealed for the first time in 1874. Our late King Victor Emmanuel, when undertaking, near the end of that year, some excavations on his hunting estate of Castel Porziano, between Ostia and Torre Paterno, discovered the public square or forum of a village, named Vicus Augustanus Laurentium, mentioned by Pliny the younger as adjoining his famous Laurentine villa. In the center of the square stood the marble pedestal of a statue, raised by the worthy inhabitants of the village in memory of a local benefactor named P. Aelius Liberalis, a freedman of the Emperor Hadrian. As usual, the career of the gentleman so highly esteemed by his fellow-citizens is described in the legend on the pedestal. We are told by it how Liberalis began his career in the finance department as cashier of the branch office for the importation of breadstuffs, which had been established at Ostia as the landing place of the fleets laden with the harvest of all the provinces of the empire. In course of time he was elected to another office, *procurator pugillationis et ad naves vagas*—'postmaster of Ostia and superintendent of despatch boats.'

[1]By permission of the publishers, Houghton, Mifflin & Co.

"Postal institutions, in the modern sense of the word, were not unknown in Roman times. To secure quick and accurate intelligence, even from the remotest provinces, Augustus established, all along the great highways, a system of couriers mounted on swift horses, and stationed at an average distance of seven miles from one another.

"Later on he organized a regular service of mail coaches which seems to have been brought to a higher point of perfection by the Emperor Trajan. These accommodations, however, were reserved for the benefit of government employes—such as cabinet messengers, military officers, governors, and so on—and very seldom were for the benefit of private individuals to whom the privilege of using mail coaches was granted only by the emperor himself, or by the governor of a province. At the same time all the burden of the institution had to be borne by the inhabitants of the villages and towns crossed or approached by the high road; they were compelled to supply horses, mules, and oxen, and to keep the stations in proper repair; in other words, they had to pay all the expenses of an organization from which they did not reap any advantage except the manure from the stables, graciously left them by the generosity of the government. Good, humane emperors did their best to relieve the populace from this indirect heavy taxation. There is a coin struck in honor of Nerva with a legend which signifies that the inhabitants of the peninsula at least had been exempted from compulsory supply of horses. Hadrian and Antonius seem to have met the exigencies of the service with their own purse; and, finally, Severus Alexander transferred permanently the burden from the people to the imperial treasury. The postmaster-general, styled '*praefectus vehiculorum*,' of equestrian rank, was selected generally from among retired cavalry officers; he had under his orders provincial postmasters of inferior rank.

"Such was the state of things as regards the over-land post; regarding the maritime post nothing was known until the inscription of P. Aelius Liberalis was brought to light. His double office of postmaster and master of despatch boats makes it evident that the two things were connected as two branches of the same department. There is no doubt that the *naves vagae* of the inscription were something like the *naves tabellariae* mentioned by Seneca as running in front of the fleet laden with grain from Egypt to announce its arrival at Pozzuoli, or like the *naves speculatoriae*, corresponding to the *avisos* of the modern navy. There is no doubt that, with the combined action of canvas and oars, finely-modeled ships could accomplish as quick a passage across the sea as was usually made in the first quarter of the last century. This is proved, to quote only one argument by the remarkable instance related by Plutarch, in chapter sixteen of his life of Cato, when

to impress the Senate with the necessity '*delendae Carthaginis*,' he unfolded his mantle and showed the astonished assembly a batch of fresh figs which had been gathered on the African coast only two days before."

The harbor system at Ostia was brought to absolute perfection by Trajan. He was the builder of that magnificent inner dock, which, although left fully two miles inland by the filling up of the estuary, still exists in its integrity, and is known, especially among wild-duck shooters, as the Lago Trajano, the Lake of Trajan. It had the form of a regular hexagon, 393,000 square yards in extent, with a line of quays 2,156 yards long and with a constant depth of 18 feet. The construction of Trajan's dock required the excavation and removal of 85,000,000 cubic feet of sand, and the construction of 1,940,000 cubic feet of masonry.

Communication with the sea was of far greater importance to ancient than to modern Rome, and its former facility was one of the chief factors in the attainment of the proud rank held by the mistress of the world. The coast was a favorite resort of the wealthy Romans, as the numerous villas testify; but the deposits of mud and sand left by the Tiber, especially when in flood, have thrown forward the coast line and entirely altered its appearance. It is now desolate, and is skirted by a broad belt of forest (*macchia*), where the malaria in summer is endemic. Lofty sand-hills (*tumoleti*), extending to the south beyond the Pontine Marches, bound the whole coast.

Anzio, a favorite resort of the Romans during the bathing season (June, July and August), in spite of its liability to fever, occupies the site of the ancient Antium.

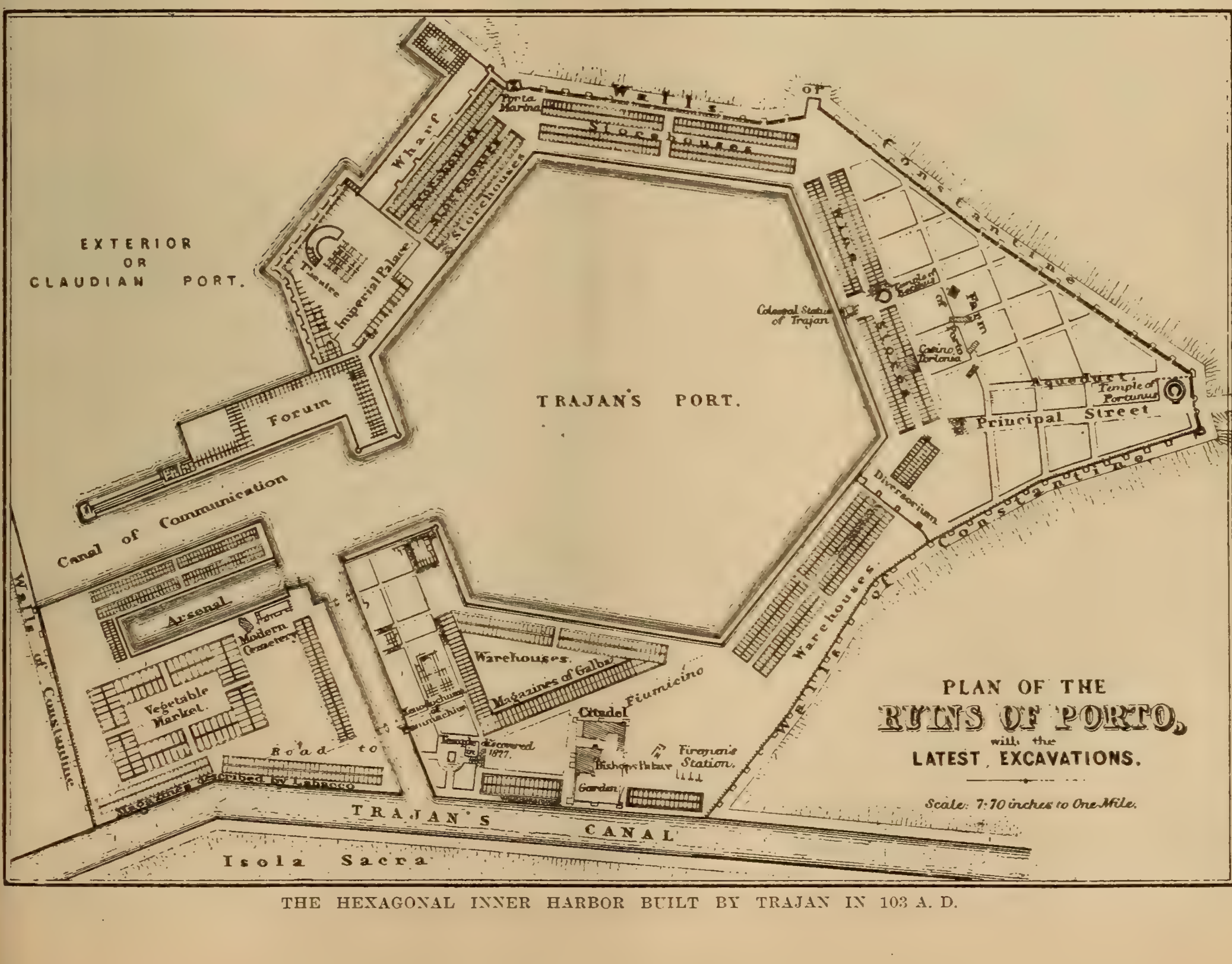
Antium, the capital of the Volsci, and a prosperous seaport at an early period, the place where Coriolanus sought refuge when banished from Rome in 490 B. C. and where he died after sparing Rome at the intercession of his mother, was compelled in 468 to succumb to the Romans. In 338, when all the Latins were conquered, Antium received a Roman colony, and was thus permanently united with Rome. Extensive villas were erected here toward the end of the republic. Cicero possessed an estate at Antium, the tranquillity and charms of which he highly extols. Caligula and Nero were born here; the latter constructed an artificial harbor. Though at a later period Antium seems to have been surpassed in popularity by Baiae and the places on the bay of Naples, the temple of Fortune, mentioned by Horace, where oracular responses were given, existed until the latest era of paganism. The place was entirely deserted in the middle ages, but in the 16th century it began to be rebuilt. The present town dates almost wholly from the period after the restoration of the harbor by Innocent XII. (1698).

The station lies close to the Piazza, and a few paces from the small harbor, which, as it opens to the south, is in continual danger of being sanded up. The remains of an ancient pier may be seen opposite in the direction of Nettuno, near the bathing establishment. Nero's harbor lay to the west of the present one; it was about 150 acres in area and was protected by a jetty of which traces are still visible above the water.

GREEK TEMPLE OF 400 B. C.

Greek archaeologists have unearthed an imposing temple at Rerras, Thessaly. The structure is in an excellent state of preservation and is stated to be as large as the temple of Jupiter at Olympia.

The bronze inscriptions establish the date as that of 400 B. C. Tablets have also been found bearing indications of laws and resolutions of ancient civilization. This is the second temple which has been discovered within a month, the first having been found near the city of Volo. The excavations are continuing.



THE HEXAGONAL INNER HARBOR BUILT BY TRAJAN IN 103 A. D.

Marine Borers in San Francisco Bay*

Serious Losses to Railway and Other Waterfront Structures Threatened by Teredo

EARLY in 1914 the activity of marine borers was noticed in the dykes of the Mare Island Navy Yard, at the upper extremity of San Pablo Bay, which is the northern arm of San Francisco Bay, as well as at two nearby points on the east shore of that bay. One of the latter was a dock between Crockett and Vallejo Junction and the other a dock at Oleum, a mile or so south of Crockett. Sporadic attacks of marine borers are reported to have been observed in that region at isolated times running as far back as 1870. In any case, these attacks were of short duration and did no serious damage. The waterfront structures erected by the industries were all built on untreated piling, because of the absence of marine borer activity in those waters and the belief that the fresh water discharged into San Pablo Bay from the combined flows of the Sacramento and San Joaquin Rivers would probably prevent any invasion of San Pablo bay by salt water, which would carry with it the various forms of marine borers.

DOCK AT OLEUM, CAL., WHICH FAILED IN 1919 AND PLUNGED SEVERAL CARS INTO THE BAY

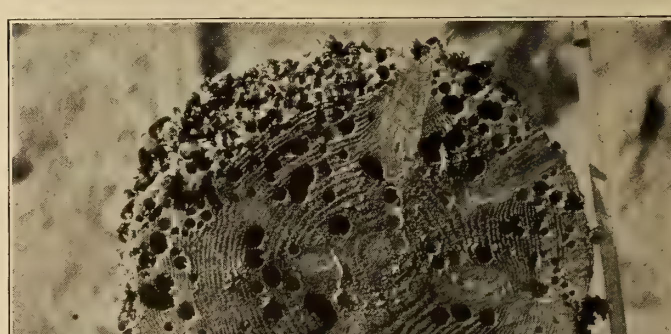
The attack of 1914 appeared to be sporadic, like the earlier ones. But at Mare Island in 1917 attacks by the same shipworm, which was identified as a teredo, again appeared, and during the following years spread very rapidly. In 1920 these failures assumed such proportions and became of such frequent occurrence that the critical nature of the local situation was brought to the attention of the officials of the American Wood Preservers' Association on June 16, 1920. As a result, a special committee was appointed on July 22, 1920, to study the marine piling problem in San Francisco Bay, with instructions to report at the seventeenth annual meeting of the association at San Francisco in January, 1921. The committee began its active work late in July, 1920.

Shortly before June 16, 1920, but practically coincident with the above action, the Forest Products Laboratory of the United States Forest Service at Madison, Wis., had proposed a plan for the study of the marine piling problem covering the entire coastal waters of the continental United States. It was the logical step to unite both proposals, and the San Francisco Bay Marine Piling Survey became, therefore, the first unit of the proposed nation-wide program of the Forest Products Laboratory, under joint coöperation with the American Wood Preservers' Association. The committee was organized with Frank D. Mattos, manager treating plant, Southern Pacific, Oakland, Cal., chairman, and included some 20 engineers connected with industries and railways interested in this problem.

The objects of the survey were to determine the extent of the damage from marine borers in San Francisco Bay, especially that of excessive severity which has occurred within the last three years in the northern portion of the bay; to determine the present distribution of the several marine borers and as much of their past history in the bay as it was possible to learn; to increase the present knowledge of the dissemination, growth and habits of the borers; to study the factors influencing the rate of attack and amount of damage from them, including the effect of climate and river discharge upon the salinity conditions in the bay; to throw more light upon the effectiveness, both in physical life and economic advantage, of the various methods of protecting wooden piling, and of the substitutes for it, together with the best methods of construction which have been developed; and to correct data on the relative costs of the different methods of protection and construction.

The name "San Francisco Bay" is technically applied only to the larger and more important southern arm of the body of water which has its connection with the Pacific Ocean through the Golden Gate. The name is more often used than any other, however, when it is desired to indicate the entire body of water. This larger bay has its longer dimensions closely parallel to the seacoast. It is 52 statute miles in its greatest length in a single direction, and has a maximum width of slightly under 12 miles. The outlet through the Golden Gate is at a point about three-fifths of the total length of the bay from south to north. At a point about one-half of the remaining distance north from the Golden Gate the width of the bay is reduced to a little over one mile, and that point marks the division between San Francisco Bay proper and the upper area known as San Pablo Bay.

At the eastern end of San Pablo Bay there enters a channel known as Carquinez Straits, through which the combined flow of the Sacramento and San Joaquin Rivers is discharged into San Pablo Bay. The Carquinez Straits are from seven to eight miles in length and above them is a large area of water composed of many tidal flats and salt marshes known as Suisun Bay. At a point about 18 miles above Carquinez Straits is the junction of the Sacramento and San Joaquin Rivers.



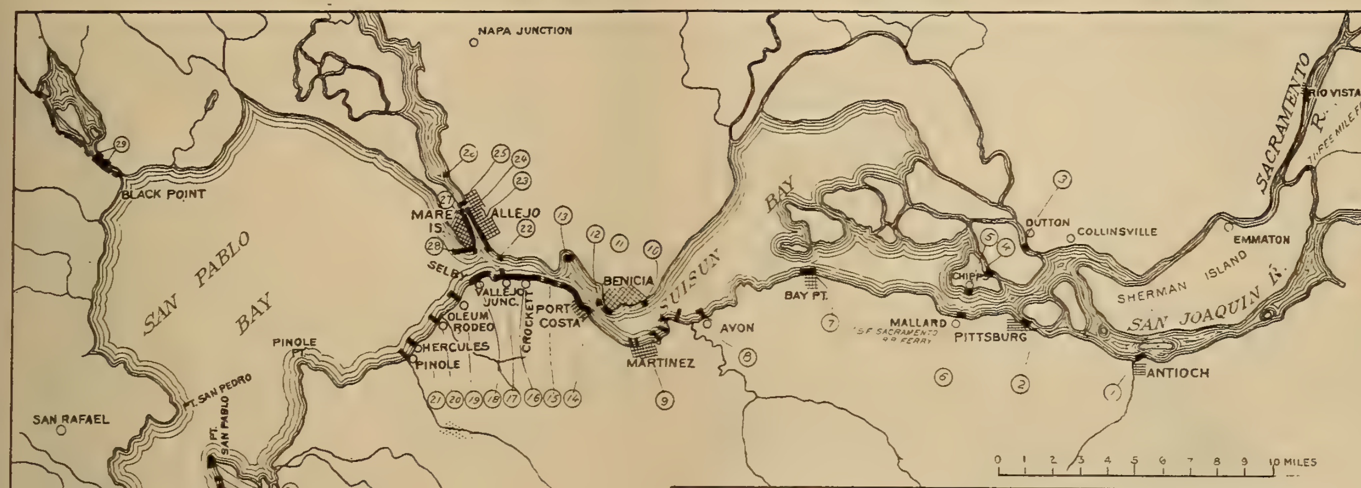
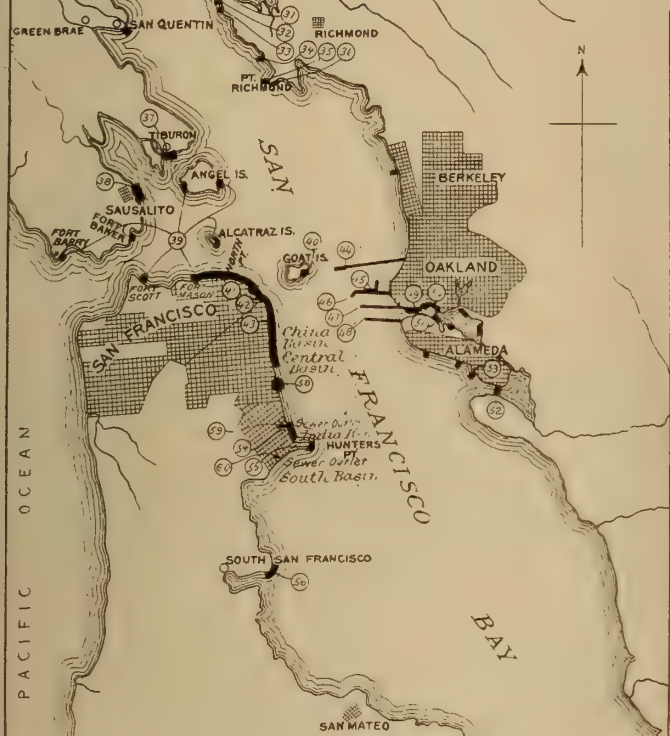
ACTION OF XYLOTRYA (LARGE HOLES) AND TEREDO (SMALLER HOLES) IN PILE AFTER 2½ YEARS' SERVICE

Destruction from marine borers in San Francisco Bay has been most active in the regions nearest the Golden Gate, where unprotected timber is destroyed within a few months. Destruction is nearly as rapid southward around the San Francisco waterfront. On the Oakland side destruction is

*Abstracted from an elaborate report of the San Francisco Bay Marine Piling Committee of the American Wood Preservers' Association, and presented at the annual convention of that association in San Francisco on January 2. Reprinted from *Railway Age* Feb. 18, 1921.

somewhat less rapid, unprotected piling lasting from 18 months to three years. In the Oakland estuary the activity of limnoria is greater than that of the xylotrya and piling may be destroyed in as short a time as six months.

In the northern area, including the lower course of the Sacramento River, Suisun Bay, Carquinez Straits and the adjacent portions of San Pablo Bay, many of the piling structures, although built wholly of untreated wood, had stood from 30 to 40 years. The destruction there since 1917 by the teredo has been swift and unusually severe. Every waterfront structure as far upstream as Antioch has been attacked by the teredo. This year (1920) the waters of Suisun Bay had reached their maximum salinity about the middle of September and, a few weeks later, particularly after the winter rains commenced, the increasing flow of the rivers accelerated the freshening of the water in the upper end of Suisun Bay, so that by the middle of November the brackish water had there been displaced. The seasonal rainfall at the end of December (July 1 to December 31, 1920), has been about 40 per cent in excess of the normal. At the time of greatest salinity during 1920 the bay water at Collinsville, just below the mouths of the two rivers, at high tide, slack water was about one-half ocean water; and at low tide slack water somewhat less than one-third ocean water.

MAP OF SAN FRANCISCO BAY

During the low water period of these recent years the irrigation draft upon the Sacramento and San Joaquin rivers was increasingly heavy, largely due to rice growing in the Sacramento Valley, and there was a period of several months of the year 1920 during which it seems to have been a fact that more water was used for irrigation on the delta lands of these rivers than was supplied to the delta channels by the two rivers. In such circumstances some of the bay water which entered the mouths of the rivers on each flood tide was retained in the river channels and caused bay water, under the influence of tidal action, to get up stream at high tide to points in the Sacramento River somewhat above Isleton and in the San Joaquin River to points probably above the mouth of Middle River. The salinity records of the State Water Commission show a chlorine content on the San Joaquin River at Blake's Landing (Venice Island) in September, 1920, of 56 parts in 100,000 at high tide and 40 parts at low tide, representing about 92 parts and 66 parts of common salt, respectively. The highest salinity was shown by the samples taken on November 22. The chlorine content of the water was then 66 parts in 100,000. This is equivalent to about 99 parts of common salt in 100,000 parts of water. The situation relating to the up-river penetration of bay water is aggravated by the work of channel enlargement in progress since 1913.

THE XYLOTRYA

The cosmopolitan character of the distribution of the marine borers depends upon the ease with which their larval stages may be carried by currents of the sea, or in the water tanks of steamers, and upon the facility with which the borers themselves may travel long distances in driftwood, in exposed wood of vessels or in timber rafted by sea. This makes it a biological certainty that all great ports are subject to repeated invasions by borers from other localities.

The xylotrya is the largest of the three borers found in the bay. When full grown in our waters it measures as high as two feet in length and has a diameter at the head or shell-bearing end of three-fourths of an inch. Tubes over three feet in length and seven-eighths of an inch in diameter have been found in old piling on the San Francisco waterfront. Its burrows differ from those of the two species of teredo found in San Francisco Bay in two important particulars. They are larger and they present continuous minor deviations from the straight or curved course which teredo pursues. Their burrows are therefore less symmetrical and regular than those of teredo. The burrow of xylotrya enters the pile at right angles to the surface as a small pin hole and turns obliquely, usually downward, enlarging rapidly within two inches of the surface to one-quarter inch and within four inches to three-eighths to one-half inch. It does not restrict its course to sap wood, and in cases of sparse seeding of the

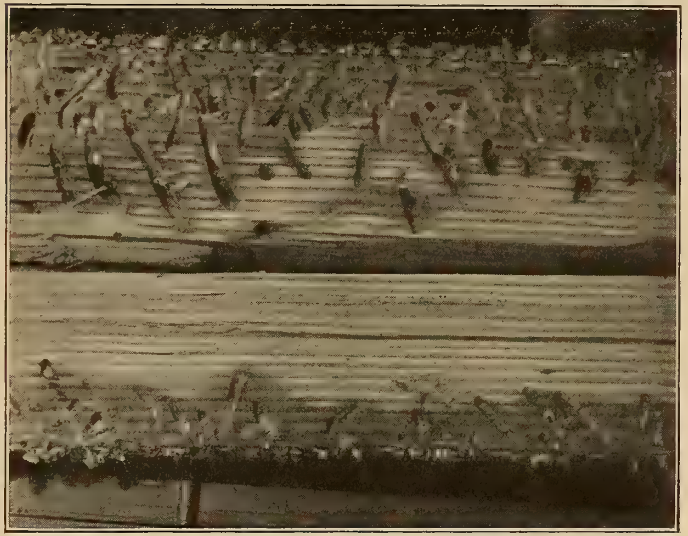
borers, often bores obliquely deep into the wood before turning to run with the grain of the timber. For this reason surface samples may not reveal lightly infected piling.

Xylotrya is generally found in association with limnoria in our waters and the two invade the pile together, although it is probable that when once limnoria gets possession of the surface, xylotrya has a small chance to get into wood. However, creosote-treated piling hollowed out by limnoria sometimes has a few xylotrya at work within creosoted shell but not traversing it.

The rate of growth of xylotrya under existing conditions in the bay is seen in the fact that piles in the dolphin off the Alameda Mole, driven in February, 1919, were so weakened at the mud-line, mainly by xylotrya, that they had to be removed in November, 1920, that is in about 20 months. Piling in the neighborhood of the Golden Gate last only six months, owing to the combined action of xylotrya and limnoria. In so far then as our data go, it appears that the principal molluscan borer to be guarded against in the main and lower parts of San Francisco Bay and on the ocean front where salinities are those normal to the sea or approach it is xylotrya.

THE TEREDO

The teredo navalis is the ship-worm of the dykes of Holland. This species is the medium-sized species of the three molluscan borers occurring in this region. It is, when full grown in the autumn, from 4 to 10 inches in length, generally 6 to 8, and the diameter of the head end is from 1/4 to 3/8 inch. The body lies in the burrow which enters the pile horizontally, and generally, but not always, turns downward at once and expands within one or two inches to a nearly uniform diameter throughout the rest of its course.



PENETRATION OF TEREDO FOUR INCHES INTO GREEN DOUGLAS FIR PILE IN FOUR MONTHS

The tubes or burrows of teredo differ from those of xylotrya in our timbers in being smaller and somewhat more thickly set or crowded. They enter the piling less deeply than xylotrya, whose burrows, whether few or many, are wont to enter the pile even to the center, while teredo enters deeply only by reason of crowding. Moreover, xylotrya works in shallow water less readily than teredo. When crowded the burrows are often only 1/8 inch in diameter. The burrows enter by minute holes 0.008 inch in diameter when first made, but enlarged to as much as 0.03 as the animal grows older. The burrow runs a curved or straight course, often with the grain and downward when not crowded, or more or less obliquely across it when crowded.

The burrows twist and turn to avoid crossing each other and the direction of the tube may even be abruptly reversed in a short turn, or the inner end abandoned and a new course established at a point above it. They are generally straighter or more regularly curved, and have smoother walls.

The degree of destruction of the timber by excavation is a function of the density of settlement and penetration. In piling with a fairly heavy infection from Port Costa, we find that in four samples the average per cent excavated was 45.5 per cent. In densely attacked timber, the percentage of excavation will run somewhat higher than these figures.

In December, 1919, it was found that teredo had penetrated the piling of the Southern Pacific slips at Port Costa and Benicia two to three inches, and in some instances had almost completely eaten the pile through at the mud-line. A pile pulled at Vallejo Junction in June, 1919, and sawn in two-foot sections, did not contain teredo, nor was it found in surface sampling at low tide on Southern Pacific structures in the upper bay in June, with surface salinities of 3.3 parts per 1,000, but was detected in great numbers on October 15, 1919, in surface and bottom salinities of 22 parts per 1,000, at Vallejo-Junction when a steamer broke off some piling, and shortly thereafter at Port Costa and Benicia, in surface salinities of 12.1 and bottom of 17.6 parts per 1,000, in pulled piling. By the autumn of 1920 they spread up stream until they had reached Antioch on the San Joaquin, 25 miles above Carquinez Straits and 50 miles from the Golden Gate, and up the sloughs of the Delta to Dutton.

This progressive invasion was the direct result of the continued shortage in the annual rainfall and run-off during these years, which permitted the settling of the larval stages on unprotected piling during the breeding season of midsummer and the survival of the borers in the wood during the brief season of the spring freshets of these years. In the upper bay from Pinole through Oleum, Mare Island, Vallejo, Crockett, Port Costa, Venicia, Martinez, to Mococo and Avon, the destruction of piling by this teredo in the summer of 1920 reached a climax which left little or no untreated piling undamaged and not a little of it wholly destroyed by penetration to the center or near it, at the mud-line.

In the meantime the invasion had spread elsewhere to unprotected structures, such as those above Black Point on Petaluma Creek, to the wharves at Richmond, and to the unprotected piling of the dolphins of the Alameda Mole, to some points in the Oakland Estuary, to the Bay Farm Island Bridge, and to the Dumbarton cut-off at the southern end of the bay. It was also found during the survey at South San Francisco, in the Bay View sewer outlet, and at the sewer outlet at Hunter's Point, in new piling in the boom at Islais Creek, and sparingly at Pier 7 on the San Francisco waterfront in treated piling which had been opened up by the attack of limnoria. From the distribution thus shown it is to be inferred that all unprotected piling in San Francisco Bay may be expected to show upon examination an attack by this borer.

THE LIMNORIA

In addition to the molluscan borers attacking marine structures described above, there are three others belonging to the crustacea of general distribution, namely limnoria, sphaeroma, and chelura. Limnoria and sphaeroma only have been found as yet in San Francisco Bay. These borers owe their efficiency as destroyers of wood to their powerful biting jaws by which they cut their way into the hardest of wood. They both belong to types of crustaceans adapted to life in the zone of extreme environmental conditions, between tides where moisture, light, salinity, temperature, food supply, and stabiliy of the substrate are subject to rapid and extreme change. The body of the limnoria is small, the largest individuals attaining a length of 1/4 inch and one-third as wide. It is elongate slipper-shaped, flattened dorso-ventrally, and has rounded ends.

Limnoria is found on both the Atlantic and Pacific shores of the United States, north to Bering Island, and has been reported on European coasts from the Adriatic to Norway. It is common along the California coast in piling on the ocean

front. In San Francisco Bay it is very destructive in the Golden Gate, on the Oakland and San Francisco waterfronts, at Dumbarton cut-off and at Sausalito, Tiburon and Richmond. It was not found north of San Quentin and San Pablo Point and took no part in the invasion of the Upper Bay with teredo. It is thus abundant where salinity is not much reduced by fresh water.

Limnoria destroys piling by gnawing its interlacing branching burrows into the surface of the wood. We have found from 200 to 240 burrows per square inch in heavily attacked timber. These burrows are from 0.050 to 0.025 inch in diameter and follow the softer zones of spring growth between the more resinous harder zones of the annual rings. Piling infested by limnoria thus has an outer scurf of ⅛ to 3/16, rarely ¾ inch of perforated somewhat laminated wood, which is readily broken or falls away as the attack proceeds. In square timbers the attack progresses rapidly between the harder zones of the annual rings on radial sections, leaving these resinous strips as projecting ribs.

The borer is particularly insidious in its attacks upon creosoted piling because of its habit of creeping into small crevices. If cracks open through the saturated zone of a creosoted pile or if bolt or dog holes or peavy holes or other breaks in the continuity of this protection occur, limnoria is sure to find its way into the retreat thus offered and to begin its destructive work. It will reduce such a pile to a mere shell. It is sometimes found in such piles actually at work in the creosoted zone itself. Whether it does this because it slowly becomes acclimatized to the repellent substance or because of defective creosoting, low grade oil, or progressive leaching out of the toxic elements of the oil, is unknown.

The proportion of the wood removed by limnoria in its burrows is somewhat less than that removed by teredo. Teredo-eaten piling has a firmer consistency because of the thicker partitions between the burrows. Limnoria-eaten wood is more friable or spongy because of the numerous small burrows and the more or less elastic resin zones left somewhat intact by these borers.

A test of the average amount of excavation in five pieces of Douglas fir squared timber eaten by limnoria from Tiburon showed an average of 42.8 per cent. The considerable number of borers remaining in the burrows somewhat reduces the apparent volume of the excavation. The probability is that it is often in excess of 40 per cent.

FAILURE OF A CORBEL ON PILE CUT OFF TOO CLOSE TO WATER, BARNACLES INDICATE HIGH WATER LINE

THE SPHAEROMA

The sphaeroma is a larger, stouter form than limnoria, but with the same general structure. The body is broadly ellipsoidal in outline seen from above with rounded ends. It is one-half inch long and one-quarter inch wide and rolls up into a ball about a quarter of an inch in diameter when disturbed. Its color is dark olive to slightly reddish brown. It is often mottled or blotched with lighter dull yellowish areas on the middle of the back. The eyes are prominent and lateral in position.

Sphaeroma is very often found in crevices or other sheltering nooks outside of its burrows and is evidently something of a forager. It does not appear to depend upon the wood eroded from its burrow for food, for its stomach contents are made up of the minute vegetable and other growths which cover the surface of the piling.

SECTION OF UNTREATED DOUGLAS FIR PILE; 7 YEARS' SERVICE

PILE BROKEN FROM PIER AFTER 2½ YEARS' SERVICE

The excavations made by sphaeroma pentodon in marine structures are very characteristic in size, distribution and location. They have circular openings up to nearly one-half inch in diameter, enter the wood horizontally or turn more or less abruptly and run with the grain in the softer layers of the wood. They do not exhibit the expansion characteristic of the molluscan burrows.

Sphaeroma works mainly between high and low tide, though found at all levels on piling. Its workings are obscured in deeper water by the more intense activities of limnoria and the growth of other marine organisms. Between tide levels it gives to the piling a pitted appearance with its large, open, dark-colored burrows. Its work is erratic in that often only certain piles are subject to its attacks while neighboring ones may be untouched. It sometimes runs channels on the surface of wood, especially in the more deeply submerged piling.

The sphaeroma has a wide range of distribution in our locality. It has been found at Sausalito, Tiburon, Black Point, the Mare Island dikes, in Napa Creek, along Carquinez Strait and upstream to Antioch in water of low salinity. It also occurs along the western water front and Oakland Estuary and in the southern part of the bay to South San Francisco and the Dumbarton cut-off. It is known to occur northward to Alaska.

EXTERIOR INDICATIONS OF MARINE BORERS

The crustacean borers work upon the surface of submerged wood and leave an open record of their destructive activities in the erosion caused by their burrows. Limnoria and chelura erode so rapidly that few other forms of marine life can obtain, or long retain a foothold on the wood in which these borers are working.

As regards the molluscan borers, the case is different. They enter the wood as minute larvæ and leave only a pinhole to mark the places. There is nothing to indicate to the casual observer either their presence or the degree of destruction which they have accomplished.

The survey of the Sacramento River to Sacramento brought out the fact that certain forms of marine life had gone up the river as far even as Walnut Grove, and that these same forms were luxuriantly thriving on piling attacked in Carquinez Straits, as salt water had invaded that territory. They serve, therefore, as indicators to the uninitiated that the sea with its fauna is invading new territory. These marine organisms are the barnacles and the hydroids. The former are well-known crustaceans encased in an armor of shelly plates which cover piling, rocks, ships' bottoms, and any available substrate with hosts of more or less close-set, whitish, angular bodies ranging up to a hazel-nut in size. The hydroids are moss-like plant-animals which form a grayish or brownish mass or, when dead, hair-like growth over piling.

There is fortunately another marine animal of cosmopolitan distribution, the European edible mussel, mytilus edulis, whose somewhat angular black shell is attached to rocks, piling and any stable or floating substrate. The occurrence of young mussels on marine piling is a danger sign for the engineer to look out for teredo.

There is one outstanding feature of the present outbreak of marine borers in San Francisco Bay and of this survey which affects State and Federal supervision of navigable waters and of shipping and engineering practice in the construction and maintenance of marine structures, such as wharves, moles and piers. It is this, namely, that within the area infested by marine borers all unprotected woodwork is a potential breeding ground for harboring these pests, increasing their numbers, and sending forth their migrating larvæ. In every case an infected bit of wood is a contagious spot. A single infected pile in 25 feet of water and its 100 square feet of surface affords shelter for upward of 150,000 teredos, and each of these is capable of producing more than 2,000,000 larvæ per year. Each pile, barring the death rate of larvæ, thus produces enough young to seed 2,000,000 other piles.

THE ENGINEERING PROBLEM

To the engineer responsible for the design, construction and maintenance of structures in sea water, accurate information on the relative cost and the permanence of various kinds of piling and pile protections is of the greatest importance. After describing the various methods of protecting piles in some detail, the committee concluded that:

(1) Marine borers are very active in San Francisco Bay, and in places where their attack is severe will destroy untreated piling in as short a time as six to eight months. In other places the untreated piling may last two to four years.

(2) The information secured indicates that it is reasonable to expect a life of five to eight years from paint and batten protections if the work is well done. If it is not well done or if the covering is damaged by careless handling this range of life cannot be expected.

(3) When carefully handled so that there is no injury extending through the shell of treated wood within the water section, it appears possible for properly creosoted Douglas fir bearing piling to give a life of 25 to 30 years in San Francisco Bay.

(4) Most of the attack on creasoted piling by marine borers, which the committee has observed throughout this survey, appears to have begun in spots where untreated wood has been exposed by damage in handling the piles or placing the superstructure. It is urgently recommended that improvements be made in the methods of handling creosoted piles and building structures upon them, so that damage to the surface of the piles may be reduced to a minimum.

(5) Precast reinforced concrete piles and pile casings have not been in use in San Francisco Bay a sufficient length of time to determine their ultimate life. A detailed examination of those structures which have been in service for 10 years shows no evidence of deterioration and they seem capable of a long further life.

(6) Cast in place concrete pile jackets and cylinders may be expected to give satisfactory results if properly constructed of suitable materials. The difficulties of this type of construction, however, are of such a nature that the probability of securing a maximum length of life is less than in the case of precast concrete piles or pile coverings.

(7) The selection of a type of piling or pile protection for a given structure must be made upon the basis of cost and permanence of the materials under consideration, the character of the structure and the probable need for future alterations to meet the changing requirements of commerce. When a comparatively short increase over the life of green wooden piling is sufficient, the surface protections will often be found economical in waters not exposed to severe storm action; if a moderately long physical life approximating the average economic life of marine structures in this harbor is desired, a good creosote treatment will provide it at the lowest annual cost so far as present knowledge goes; if conditions warrant building for the greatest permanence, with less regard for first cost, concrete construction may be useful. For the protection from further damage of wooden piles already in place and showing attack by borers, not yet severe enough to require condemnation, the concrete casing, precast or poured in place, is the only means of salvage so far found by the committee.

YACCA GUM INDUSTRY OF SOUTH AUSTRALIA

PRIOR to the war the gathering and shipping abroad of South Australian yacca gum was an important industry on Kangaroo Island, just off the south coast of this state. As Germany was the largest user of this product, the industry was suspended during the first years of the war, and not until use had been found for it in the United Kingdom and in America during the latter part of 1916 did the production revive. In 1919 more than 10,000 tons were gathered, and as the Australian consumption is small the greater part of the output was shipped to Great Britain and to the United States. It is believed, writes the U. S. Consul of Adelaide, that further experiments in the use of this valuable product may develop a larger scope for its utilization and thus encourage the expansion of the industry at Kangaroo Island.

Before the war nearly two-thirds of the Australian output was bought by German firms. Local dealers have never been able to discover what use the Germans put it to, but it is believed that it was used in the manufacture of furniture polish and lacquer for metal ware. It should not be overlooked, however, that the product contains a high percentage of picric acid on nitration, and it it is not unlikely that it was also used by the Germans in the manufacture of explosives—a use to which it was put by the Allies in 1917 and 1918.

The gum from the species *Xanthorrhoea Hastilis* is, of course, one of the oldest known sources of picric acid, yielding about 15 per cent by treating the gum with strong nitric acid. The gum has also been used in the manufacture of dyes. To quote a technical report on the subject, "the high yield of picric acid on nitration and of paraoxy-benzoic on alkaline fusion indicates a chemical constitution for the resin of an oxygenated benzine derivative, and among such derivatives are numerous fine chemicals in daily use, viz., photographic developers and material used in the preparation of synthetic dyestuffs. The resin is also said to be of considerable importance in the manufacture of linoleum."

Experiments have shown that the gum is soluble in alcohol, but insoluble in turpentine, linseed oil, benzine, molten paraffin, and hydrocarbon solvents generally. The gum is partially soluble in cold strong sulphuric acid to a deep red solution; on dilution of the sulphuric acid solution and cleaning the brownish red solid separates. When filtered and freed from the sulphuric acid, this solid dissolves in water and is reprecipitated from its aqueous solution by the addition of a little sulphuric acid.—From the *Journal of the Royal Society of Arts*, March 25, 1921.

Errors of Direction Finders*

Influence of the Horizontal Parts of the Sending Antennae

By Dr. E. Bellini

IN the early period of the existence of the direction-finder it was generally thought that a well-constructed direction-finder apparatus, installed upon a homogeneous stretch of land and free from local influences, would give exact bearings. Experiments confirmed this idea. At that time, spark transmitters and moderate wave-lengths were used, and, since amplifiers had not then been discovered, the distance at which a station could be located was limited.

But the discovery of the amplifier, which enormously extended the range of the direction-finder, and the adoption of undamped waves of very great lengths, completely changed the working conditions of these apparatus. The satisfaction of being able to reach enormous ranges was counterbalanced by the dissatisfaction at finding a new source of errors, errors which could be attributed neither to the conditions of the earth's surface nor to the influence of neighboring bodies. The characteristics of these new errors are their magnitude and their variability. Minimum in the day time, they become larger at sunset and reach their maximum at night, becoming sometimes enormous, as much as 50, 60 and even 90 deg. There rate of change may reach several degrees per minute.

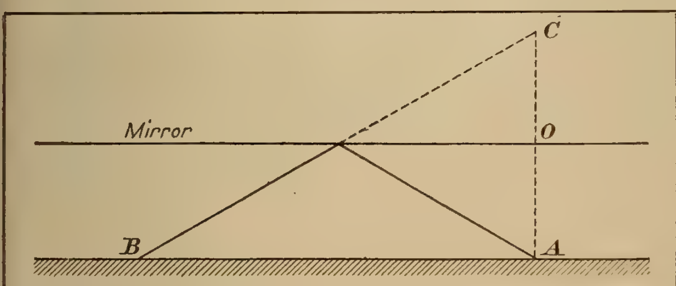


FIG. 1

THE CAUSE OF THE ERRORS

The cause of these errors has been attributed by Round,** Howe,[1] Hoyt-Taylor[2] and others to the reflection of the waves from the highly rarefied conducting strata of the atmosphere (Heaviside layer), and by Eckersley[3] to the reflection of waves from the irregularities in the Heaviside layer. In this article I hope to demonstrate that these errors are due both to the reflection of waves from the Heaviside layer, considered as homogeneous and continuous, and to the influence of the horizontal parts of the sending antennæ upon the horizontal parts of the receiving loops.

At night time the upper strata of the atmosphere are certainly conductive because of the rarefaction, while the low strata are insulating, owing to the absence of causes of ionization. The waves are reflected from the upper strata, and they, consequently, travel in the insulating medium comprised between two conductive surfaces (earth and Heaviside layer).

In the day time the light of the sun ionizes the lower strata of the atmosphere. The difference in conductibility between the upper and the lower strata of the atmosphere tends to disappear and the transmission approaches the theoretical conditions of a homogeneous medium through which the waves travel. The bearings obtained in the day time must, therefore, be in closer agreement with those obtained by theoretical considerations than those obtained at night.

DETAILS OF EXPERIMENTAL WORK

During the war a large amount of experimental work on direction finding was carried out. The most important observations and facts, which can be utilized for finding an explanation of the errors, may be summarized as follows:

(*a*) Errors are much larger at night than in the day time.

(*b*) In southern latitudes larger errors are generally obtained than in northern latitudes.

(*c*) Waves sometimes appear to come at the same time from different directions and to be shifted in phase, so that the minimum may be ill-defined or even non-existent.

(*d*) Errors are larger for long than for short waves. In particular, the bearings of the Horsea arc station, taken on the marking or on the spacing waves, differ by 30 deg. (Round).

(*e*) Errors are larger for continuous-wave than for spark stations (Round, Hoyt-Taylor).

(*f*) Errors do not exist when the distance of the located station does not exceed about 15 miles (Round).

(*g*) Some stations practically give exact bearings, both in the day time and at night. Round mentions the station of Hanover (Eilvese) and that of Malta, when located by direction-finder stations situated in England.

(*h*) Two transmitting stations placed side by side, but with differently shaped aerials, give different bearings (Round).

(*i*) A sending station utilizing a loop aerial gives different bearings according to the angular position occupied by the loop (Round).

The facts cited under (*d*), (*g*), (*h*) and (*i*) clearly show the influence of the form and excitation of the aerial of the sending station. The mere difference in conductivity of the different strata of the atmosphere cannot, therefore, account for all the facts observed.

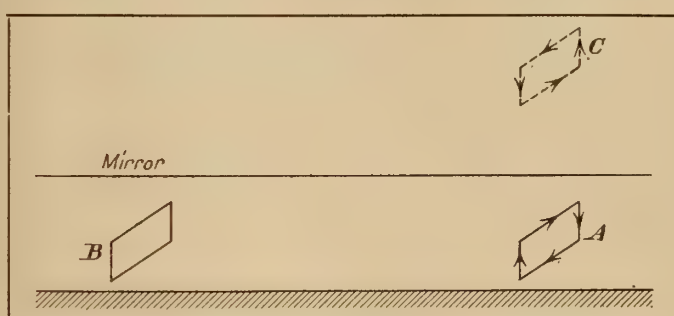


FIG. 2

AN OPTICAL ANALOGY

The reflection from the Heaviside layer can, at a first approximation, be compared with that from a horizontal reflecting mirror placed some kilometers above the earth's surface. We can apply, therefore, the ordinary rules of geometrical optics. The receiving station B (Fig. 1) will receive not only the waves directly sent from the sending station A, but also those sent from an imaginary station C placed behind the mirror on the perpendicular AO to it, at a distance $OC = OA$.

Let us suppose a sending loop A (Fig. 2) and a receiving loop B parallel to each other. If the reflection phenomena

*Reprinted from *The Electrician* (London), Feb. 18, 1921.

**Captain H. J. Round. "Direction and Position Finding." *Journal of the I. E. E.*, March, 1920; *The Electrician*, Vol. LXXXIV., p. 217, March 19, 1920.

[1]Prof. G. W. O. Howe. "The Upper Atmosphere and Radio Telegraphy." *The Radio Review*, May, 1920.

[2]Lieut.-Commander A. Hoyt-Taylor. "Variation in Direction of the Propagation of the Long Electromagnetic Waves." *Scientific Papers of the Bureau of Standards*, No. 353, Nov. 29, 1919.

[3]Cited by Round, *loc. cit.*

were not present no reception should take place, both because the sending loop A does not radiate toward the receiving loop B and because this is unable to pick up energy sent from a station placed in the direction BA. The Heaviside layer acts as if an imaginary sending loop, situated in the same vertical plane as A, existed at C. The plane of this being inclined to the direction CB at an angle less than 90 deg. will send energy to B; and the plane of this, being inclined at the same angle to the direction BC, will pick up a fraction

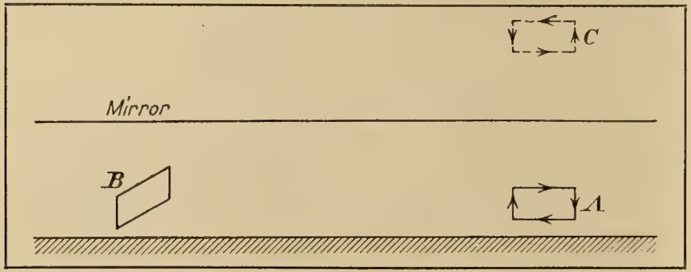


FIG. 3

of this energy. If, therefore, the receiving loop B is swung so as to determine the direction of the impinging waves, a bearing with an error of 90 deg. will be obtained. If the sending loop A (Fig. 3) is directed toward the receiving station B, the action of the image C will give the same direction as the loop A, and the bearing will be exact.

In the general case, the plane of the sending loop is inclined at a certain angle to the direction AB. The plane of the image will be inclined at a certain angle to the direction CB.

The receiving station will, therefore, receive at the same time the waves sent by A and those sent by its image C. The electromagnetic field at B will, in consequence, be the resultant of two fields of different directions and of generally different intensities and phases; it will, in general, be an elliptical rotating field. The minimum may, therefore, be good, broad, or non-existent; and if possible to obtain a bearing at all the result will be more or less inaccurate.

TRANSMITTING STATION WITH VERTICAL ANTENNA

Let us consider now a transmitting station provided with a vertical antenna A (Fig. 4). The Heaviside layer acts as if another vertical antenna C existed in the space and were contained in the same vertical plane of A. Both will give the same bearing at B and no errors will be found. The results are different if a horizontal sending antenna is con-

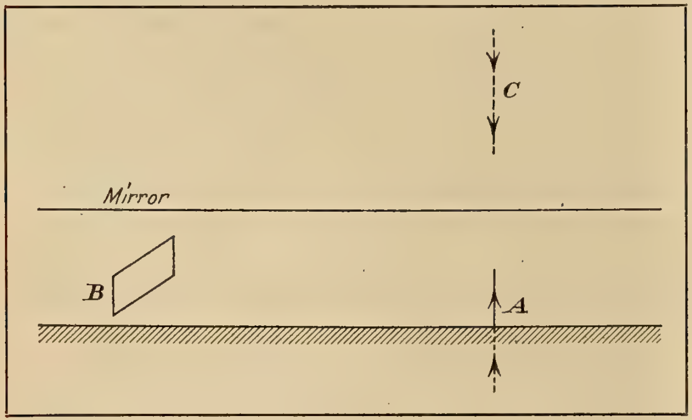


FIG. 4

sidered. If this is perpendicular to the direction AB (Fig. 5) it will not directly affect the receiving station B, but the radiation from its image C will be received at B and an error of 90 deg. in the bearing will be observed. If the horizontal antenna is directed toward B (Fig. 6) its image C will be received at B, but the bearing will be accurate.

It appears, therefore, from the above-examined particular cases that it is the influence of the horizontal sides of the sending antennæ upon the horizontal sides of the receiving loops that produces errors in direction finding. And as these errors depend upon the angular position of the sending loops, the fact cited under (i) would be explained. If a transmitting station is exclusively provided with one or more vertical antennæ, directive or otherwise, no errors should be observed. For instance, the directive sending station A (see Fig. 7), the aerial of which is formed of two vertical antennæ a fraction of wave-length apart, should according to this theory give no errors.

On the contrary, if the antenna of the direction finder could be so formed as to contain no horizontal parts, no errors in the bearings should be observed, independently of the fact that the aerial of the sending station contains or does not contain horizontal parts. In particular, the system of double loop employed by Weagant[4] as an X-stopper and the special receiving loop due to Franklin[5] (used alone, not in connection with an ordinary loop) should furnish exact bearings.

THE AIRPLANE EFFECT

The Heaviside layer acts, therefore, by producing what Round calls the "airplane effect," which means that the image of the sending station acts as an airplane station high in the sky. Consequently, the methods which have been employed for eliminating the errors in the bearings of airplane stations should be valuable for eliminating the errors in the bearings of stations on the ground.

It is known that an ordinary airplane antenna is strongly

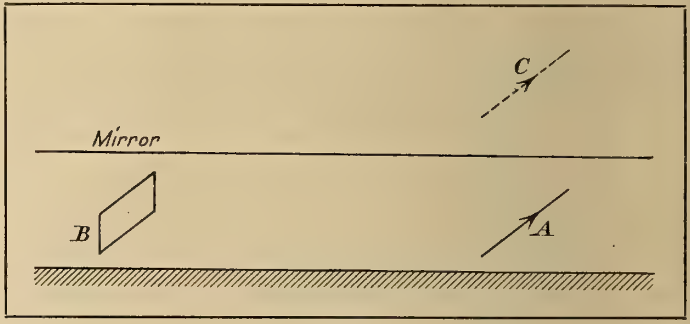


FIG. 5

directive, because it is of the form shown in Fig. 8. It is a kind of Marconi bent antenna. The bearings furnished by such an airplane antenna are wrong except when the airplane flies toward or from the direction-finding station; positions in which the action of the horizontal side is nil. Experiments have shown that if the action of the horizontal projection of the airplane antenna is eliminated, which in this case means that a non-directive antenna is employed, all errors disappear and the bearings become exact (Baldus and Buchwald[6]). This fact appears to be an indirect confirmation of the present theory.

CONFIRMATION OF THEORY

A direct confirmation would be given by the observations of the bearings of transmitting stations with rigorously vertical antennæ or with antennæ containing horizontal parts. The former stations should give exact bearings, the latter inexact results. We are able to verify the exactitude of the theory only for the station of Hanover (Eilvese). Round observed that the bearings of this station are exact. And as it is provided with an umbrella antenna,[7] which is equivalent to a vertical antenna, it verifies the theory. Round has also found that the Malta station furnishes exact bearings. Lacking

[4] R. A. Weagant. "Elimination of Strays in Wireless Telegraphy." Proceedings Inst. Radio Eng., June, 1919, and *The Electrician*, July 25, Aug. 1 and Aug. 8, 1919.

[5] C. S. Franklin. "Uni-Directional Transmitting Systems," *Wireless Age*, June, 1919.

[6] R. Baldus and E. Buchwald, "Versuche über drahtlose Antheilung von Flugzeugen," *Jahrb.d. Drahtl. Tele.*, March, 1920.

[7] A. S. M. Sörensen, "Wireless Station at Eilvese (Hanover)," "E.T.Z.," May 22, 1919.

information about the antenna of this station, it is not possible to ascertain if it verifies or not the present theory.

According to this idea, it is not surprising that almost all the long-wave stations furnish inaccurate bearings. As a matter of fact, the antennæ of these stations are almost all of the Marconi bent type. They must, therefore, give bad bearings except in the particular cases where the directive finding station is in the vertical plane containing the horizontal part

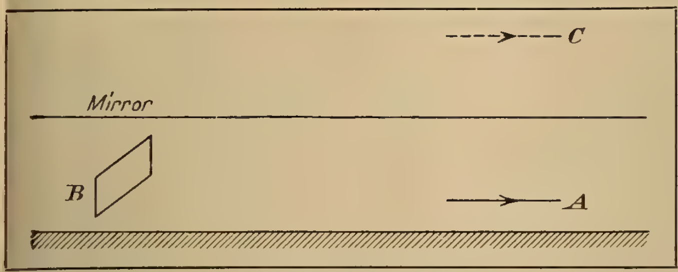


FIG. 6

of the antenna. The observed fact that long waves furnish the more inaccurate bearings than short waves can be equally attributed to the circumstances that for long waves the type of antenna adopted is the bent antenna, the horizontal side of which is longer the longer the wave. To the same cause may be attributed the fact that continuous waves give larger errors than spark stations, as continuous waves are generally longer than spark waves.

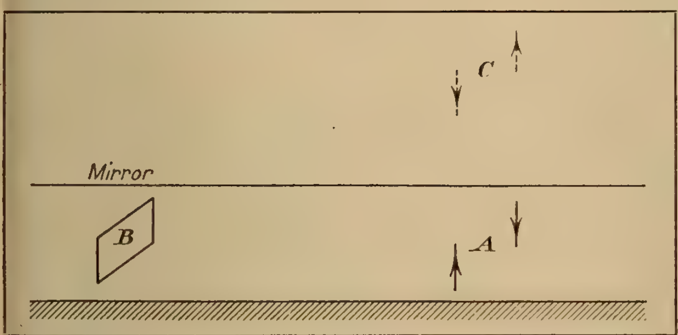


FIG. 7

THE HORSEA ERRORS

The phenomenon observed in the Horsea arc station, which furnishes different bearings when the marking or the spacing wave is utilized, may be attributed to the fact that the current distributes itself differently in the antenna according to the wave-length used; the action of the horizontal side will, therefore, be more or less pronounced in comparison with the

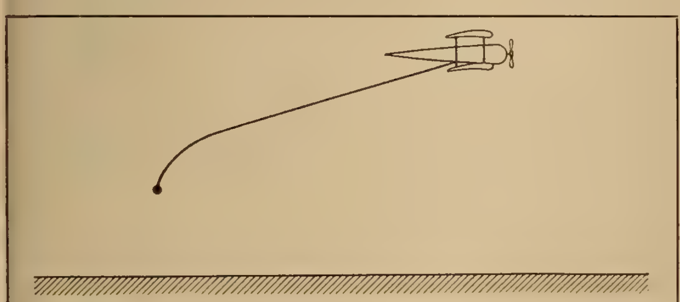


FIG. 8

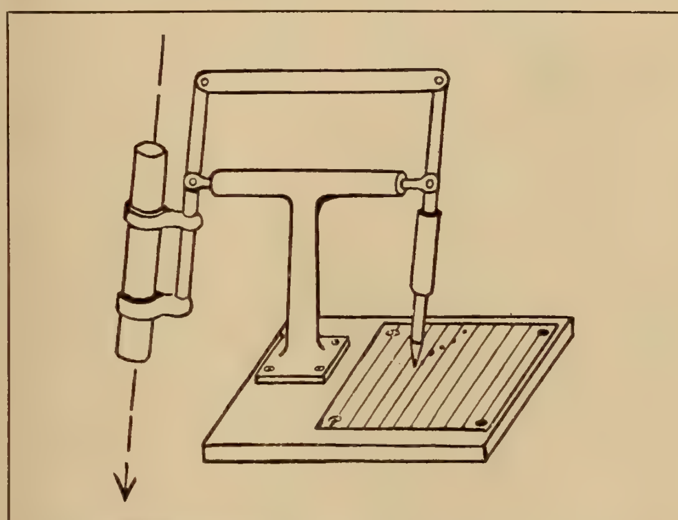
action of the vertical side, according to the wave-length used. If the transmitting and the receiving stations are not too far from one another, the action of the image, which is presumably very high in the sky, may become negligible in comparison with the direct action of the transmitting station, so that errors can be small or non-existent. In this manner the fact that when the located station is not farther than 15 miles its bearings are accurate, whatever the type of the sending aerial may be, can be explained.

This rough sketch of a new theory requires further experimental proofs before it can be accepted or rejected. In the event that it were recognized as accurate, it would have as its first practical result that it would be obligatory to revert to the original Marconi antenna or to its equivalents in transmitting stations destined to serve as beacons for directional wireless telegraphy.

THE DRIFTOGRAPH

The French scientist, M. Le Prieur, presented to the French Academy of Sciences, at its session of October 18, 1920, a new method of aerial navigation, an abstract of which we take from *Le Génie Civil* (Paris) of November 6, 1920.

The route corrector with which we are here concerned affords a solution of the general problem of aerial navigation by dead reckoning, *i.e.*, that which consists in moving in a straight line from one point to another by automatically correcting the divergence due to the wind, the pilot being provided, of course, with a compensated compass. This apparatus is based upon the observation of the drift at two different quarters. A graphic record of these two drifts instantly enables the observer to determine the force and direction of the prevailing wind, the path to follow being then readily deduced.



Courtesy of *Aeronautical Engineering*
INSTRUMENT FOR DETERMINING THE DRIFT OF AIRCRAFT

Determination of the Drift.—The sole method hitherto employed consists in observing the ground through a network of parallel wires which is oriented in the direction of the apparent displacement of points upon the ground. But this method, which is entirely theoretical, meets in practice with serious difficulties due to rolling, pitching, and more particularly to yawing or lurching.

M. Le Prieur determines the drift by means of an auxiliary apparatus, the "*driftograph*," which shows the average drift by means of a graphic record and thus eliminates the causes of error mentioned above.

The pilot observes any point whatever upon the ground by means of a sighting tube or telescope. The telescope is connected by means of a parallel link motion with a pencil which may be pressed at will upon a sheet of paper placed upon a horizontal board. Every time the point coincides precisely with the hair lines of the telescope the observer presses upon the pencil: in this manner he draws a dotted line which faithfully registers the relative displacements of the aircraft and the ground. The more accentuated the rolling, pitching and rocking the more sinuous the nature of the line drawn, but it is always inscribed without hesitation, or tentative efforts, and the average direction of the drift is deduced merely from the general trend of the dotted line. Evidently this operation requires but a brief time. Even when three or four

points on the ground are sighted to obtain the desired information, not more than a couple of minutes are needed to find the average drift within approximately one degree.

The observer may also operate as follows:

Let us suppose that the recording board is placed, not horizontally, but vertically, and in a plane perpendicular to the axis of the craft, the observer being placed upon the axis and facing the rear. If he now sights the horizon he will trace a horizontal line; if he then sights the axial plane of the aircraft (the tail of the latter) he will trace a vertical line. This being done, if he next sights points upon the ground he will obtain dotted lines which will all cut the line of the horizon at the same point which coincides with the vanishing point of the parallel lines represented by the relative displacement of all points upon the ground with respect to the observer. The divergence between this point and the vertical line will exactly measure the drift, thus affording a new method of determining the drift and consequently the corrected route. This method is particularly valuable when the ground itself is hidden by clouds but when a few points along the horizon are still visible.

The Route Corrector—When the aircraft has navigated two different quarters in succession the drifts obtained by means of the driftograph enable the observer to trace upon a circular sheet of paper marked with the compass points and kept in a fixed position by means of the compass, two straight lines and a line drawn from the center of the sheet to the lines. Intersection of these lines gives the velocity and direction of the "prevailing wind."

In this manner the direction of the wind is determined in less than 5 minutes and the corrected route is at once deduced. It is transmitted automatically to a repeater operated by a flexible shaft and placed under the eyes of the pilot.

SUMMARY

To sum up the matter this method which was very conclusively tested on August 28, 1920, in an airplane flying from Villacoublay to Melun and back, affords a prospect of navigating the air under conditions of admirable security. It is possible to register the variations of the prevailing wind in the strata of air traversed and immediately to deduce therefrom the required corrections of the route. For this purpose it is only necessary to discern points upon the ground without having to identify their position upon the map. For oversea trips small clouds of phosphorous fumes can be employed, set off at regular intervals. These form landmarks which are easy to see.

The safe functioning of the apparatus is not dependent upon any sort of delicate mechanism. It is always ready for use—in short, the graphic method which it employs makes it possible to control the course of navigation and to furnish valuable meteorological data.

BALLOON RACING—A GAME OF PRACTICAL METEOROLOGY

By Ralph H. Upson

Meteorology is no more an exact science than medicine is. To be sure, there *are* laws and principles that can be implicitly relied upon, but the great bulk of our future development for some time to come must depend on the accumulation and coordination of plain *facts*, *experience*, and *practice*. The performance of any aircraft (whether heavier- or lighter-than-air) is a resultant of two factors: (*a*) The power plant of the craft, and (*b*) the surrounding air, or broadly speaking—the weather.

As in other branches of science, the best way to study this important subject from a practical standpoint is to separate it as far as possible from outside influences which only disturb the observations and confuse the result. The free balloon is almost ideally suited to our present purpose for the following reasons:

1. Having no motor, its control is entirely dependent on coordination with existing weather conditions. The performance of a balloon is like that of a free particle of air with the addition of altitude control.

2. The entire freedom from pitching, vibration, noise and wind, permits the most delicate observations to be made.

3. Its simplicity and safety of operation makes a balloon especially desirable for a great variety of experiments. A free balloon is so safe that it is *practically* fool proof.

The highest art of ballooning finds expression in the national and international races for distance which are held every year. These commonly run anywhere from 400 to 1,200 miles' distance and 18 to 60 hours' duration. Having been a loser myself in the last big race, I need not be at all bashful to say that one of these races will draw on almost every talent that a man has—knowledge of navigation and meteorology, experience in its application, ability to size up the actual conditions, good judgment in their interpretation, practical skill in handling the balloon, firmness in adhering to a good plan of action but always with eyes and mind open for a better one, courage or caution where necessary, and plenty of plain physical endurance without forgetting good sportsmanship; these are a few of the qualities one can use to advantage in a balloon race. Of the nine international races for the Gordon Bennett cup since 1906, Belgium has been winner once, France once, Switzerland once, Germany twice, and the United States four times. This year the races will start from Belgium because of the Belgian lieutenant, de Muyter's, victory last year.

The history of balloon racing up to the present time shows conclusively that it is taking on more and more of a meteorological character. In the past, races have been occasionally won by mere practical skill in operation of the balloon, but the time when this is possible is rapidly passing, if indeed it has not already passed. In the future, meteorological knowledge instead of being a secondary factor in the assets of a team, will be absolutely the controlling factor.

The record of the race from Birmingham, Ala., last fall is a very interesting study in this connection. The winner was a trained meteorologist besides being a good balloon pilot. His performance in that race sounds almost incredible, but the facts cannot be avoided. He, the winner, among all those who really stayed in the race, landed the very earliest. All started from Birmingham, Ala., between 5:30 and 6 P. M., October 23. At 9:30 A. M. of October 25 the winner was landing in the State of Vermont, while most of the other balloons were floating gently over Indiana and Michigan. One of these (we need not mention names) had ballast in plenty for another 24 hours, but would have needed twice that length of time to reach the distance marked off by the winner. At 2 o'clock in the afternoon (of the third day) a landing was finally made near Detroit, at approximately the same spot that the winner had passed over about 16 hours before.

These are striking coincidences, it must be admitted, but there is plenty of other evidence at least as strong showing the great importance of meteorology in modern balloon racing. And the shoe fits both ways. Not only does balloon racing need meteorologists for its best development, but meteorologists need the experience and stimulus which free ballooning is best able to give.

Ballooning is by all odds the best practical training for anyone who would use weather knowledge. Then why not for professional meteorologists? To be perfectly frank, ballooning is no longer important for the making of structural experiments from an engineering standpoint. The more definitely practical types of aircraft, such as airships and kite balloons, have reached a point where they are no longer dependent on free balloon experience for their structural requirements. But the keen struggle of wits against weather and the wonderful spirit of adventure which is an intimate part of even the shortest balloon flight, will always keep alive this fine sport.—Abstracted from the *Monthly Weather Review* Jan., 1921. Article written Feb. 25, 1921.

THE L.72 ZEPPELIN—ONE OF THE LARGEST RIGID DIRIGIBLES EVER CONSTRUCTED BY THE GERMANS AND TURNED OVER TO THE ALLIES AFTER THE ARMISTICE

German Airship Construction During the War

The Remarkable Development of Germany's Aerial Armada During the Period of Hostilities

By Ladislas d'Orcy

FEW efforts in the history of world armaments may be said to parallel in their intensity the creation of the airship fleet by the use of which Germany intended to become supreme in the air and so attain the mastery of the world. Despite repeated setbacks, involving huge monetary losses, to which the war added severe casualties, the forging of this weapon went on unabated for ten years—till the armistice spelled the doom of Germany's mighty aerial armada.

The magnitude of this effort may be appreciated from the fact that between 1908 and 1918 Germany launched and commissioned a total of 140 war airships, of which number 14 were at hand when the war broke out and 109 were built during the period of hostilities. Of the latter all but three airships were of the rigid type and of a size vastly exceeding anything the Allies produced in this line, the capacity of these vessels running from 800,000 cubic feet to 2,400,000 cubic feet, the horsepower from 630 to 2,000, the maximum speed from 52 m.p.h to 77 m.p.h. and the useful load from 9 tons[1] to 52 tons.

The constructional features of these ships as well as their production figures formed a strict secret during the war and the Germans even succeeded in withholding much valuable information until recently. As a consequence much of the data published hitherto on this subject is only approximately accurate, while some of it is absolutely inaccurate. The accompanying tables, having been compiled from reliable German documents, afford the first precise information on Germany's airship construction and airship losses during the war.

Table I shows the principal constructional features and performances of all the airships used by the German Empire during the war. It strikingly illustrates the means by which our late enemies attempted and achieved improved performance, now by adding a gas cell, now by increasing the horsepower, now by lightening the construction, until, having exhausted every possible means of improvement for a given type, they were forced to seek further progress in a much larger type of ship. And as soon as the latter would pass its acceptance tests and be put into production, the same process of detail improvements would be applied to it.

As a result of this policy which was applied only to the rigid Zeppelin and Schutte-Lanz ships—the number of basic types was kept down to a minimum and airship construction became strictly a production problem. With reference to the Zeppelin airships it may be seen from the table that there were actually but three production types, namely, those having a diameter of 49 feet, 61 feet and 79 feet, respectively, the Z.XII-L.9 class being an experimental one. The advantages of this system from the viewpoint of production are particularly obvious in the case of the Zeppelin airships, where the framework is composed of punch pressed duralumin rails and webs which are assembled into triangular girders. As these girders run longitudinally and transversely, the latter forming on the 79-foot diameter type a number of 25-sided polygons, the importance of having a minimum of standard parts becomes evident. This is further emphasized by the fact that each gas cell—that part of the framework comprised between two or three polygon frames—is braced by a large number of diagonal and radial wires, for which again a standard length is desirable.

Another reason which prompted the Germans to adopt a small number of standard diameters was the limit in height of their airship sheds. It is a curious fact that even the Germans—who are often assumed to foresee everything—did not think far ahead enough to provide housing facilities for the inevitable increase in size of their airships. They built, it is true, sheds wide enough to hold two ships side by side, but for their larger Zeppelins these sheds were not high enough. As a consequence, all through the war the Germans experienced much inconvenience in concentrating Zeppelin squadrons and many of their ships were lost through fire or collision owing to crammed quarters and restricted maneuvering space in front of them. Thus, on one occasion, four of their largest and most modern airships were destroyed by a fire which started in the big shed at Ahlhorn, while at another time two ships collided and burnt up in attempting to enter the Tondern shed.

During the war the Germans strove with all their might to remedy this situation by building additional sheds, but in fact this work never kept up with their airship production,

[1]Throughout this article the tonnage of airships is expressed in long tons (2,240 pounds).

TABLE I. GERMAN AIRSHIP CONSTRUCTION, 1914-1918

Type	Year	Number Built	Length Feet	Diameter Feet	Capacity Cubic Feet	Number of Gas Cells	Useful Tonnage	Number of Engines	Total Horsepower	Number of Airscrews	Speed m. p. h.	Ceiling Feet	Crew	Service
							(a) Zeppelin Airships							
Z. IV	'13	2	462	49	688,000	16	8.2	3	540	4	48	6,500	14	Army
Z. VI	'13	1	488	49	739,000	17	8.8	3	540	4	46	6,500	14	"
Z. VII	'13	2	514	49	780,000	18	8.9	3	540	4	45	7,000	14	"
L. 3	'14	6	521	49	794,000	18	9.2	3	630	4	52	8,000	14	Navy
Z. IX	'14	6												Army
Z. XII	'15	2	531	52	883,000	15	12.2	3	630	3	50	9,500	14	"
L. 9	'15	1					11.1				53	9,000	14	Navy
L. 10	'15	5	538	61	1,126,000	16	16.2	4	840	4	60	10,500	18	"
L.Z. 38	'15	8												Army
L. 15	'15	5	538	61	1,126,000	16	16.2	4	960	4	62	10,500	18	Navy
L.Z. 87	'15	4												Army
L. 20	'15	5	587	61	1,264,000	18	17.9	4	960	4	62	11,500	18	Navy
L.Z. 97	'16	7												Army
L. 30	'16	14	647	79	1,950,000	19	32.5	6	1,440	6	65	12,500	22	Navy
L.Z. 113	'16	2												Army
L. 42	'17	2	647	79	1,960,000	18	36.4	5	1,200	5	62	16,500	22	Navy
L. 44	'17	2	647	79	1,970,000	18	37.8	5	1,200	3	65	18,000	22	"
L. 48	'17	5	647	79	1,977,000	18	39.0	5	1,200	4	66	20,000	22	"
L. 53	'17	4	647	79	1,977,000	14	40.0	5	1,200	4	67	21,000	22	"
L. 57	'17	2	745	79	2,418,000	16	52.1	5	1,200	4	63	18,000	22	"
L. 60	'17	6	647	79	1,977,000	14	40.0	5	1,450	4	71	21,000	22	"
L. 70	'18	1	696	79	2,196,000	15	44.5	7	2,030	6	77	21,000	30	"
L. 71	'18	2	696	79	2,196,000	15	48.0	6	1,740	6	75	23,000	30	"
L. 100	*	..	785	97	3,812,000	14	82.0	10	2,900	10	82	24,500	40	"
							(b) Schütte-Lanz Airships							
S.L. 2	'14	1	475	59	883,000	15	8.0	4	720	4	55	8,000	14	Army
(Rebuilt, '15)			515	59	967,000	16	10.4	4	840	4	56	8,000	14	"
S.L. 3	'14	3	504	65	1,144,000	17	13.2	4	840	4	57	8,000	14	
S.L. 6	'15	2	533	65	1,235,000	18	15.8	4	840	4	57	8,500	18	Navy
S.L. 8	'15	2	574	66	1,370,000	19	19.5	4	840	4	57	11,500	18	and
S.L. 10	'15	9	574	66	1,370,000	19	21.5	4	960	4	60	11,500	18	Army
S.L. 20	'16	3	653	75	1,977,000	20	35.3	5	1,200	4	62	16,500	22	
							(c) Parseval Airships							
P. IV	'13	1	310	51	353,000	..	3.4	2	360	2	48	11,000	8	Army
P.L. 19	'14	1	303	51	364,000	..	3.3	2	360	2	48	10,000	8	Navy
P.L. 25	'15	1	396	54	494,000	..	6.0	2	420	2	44	8,000	10	"
P.L. 26	'16	1	514	62	1,059,000	..	14.0	4	840	4	50	10,000	14	"
P.L. 27	'17	1	521	64	1,105,000	..	18.0	4	960	4	56	14,500	14	"
							(d) Gross Airships							
M. IV	'14	1	395	52	688,000	..	7.0	3	480	4	52	6,500	12	Army

*Ordered from the Zeppelin Co.; construction not begun owing to the Armistice.

for about ten Zeppelins would be built in the time it took to erect a single shed of large size.

Reasons of space forbid discussing in detail all the improvements which were gradually incorporated into the German rigids and non-rigids. A few remarks, however, seem to the point.

With reference to the Zeppelin airships, the L.3 type represents pre-war design, the first ship of the series being completed just before the war. This type had a long cylindrical hull of poor aerodynamical shape, cellular rudders and elevators of high resistance, and four propellers mounted on outriggers on the sides of the hull which were driven through bevel gear shafts leading to the cars in which the engines were housed.

While this type was in production the Zeppelin Co. built the first ship of an experimental type, the Z.XII, in which an effort was made to reduce the large amount of head resistance offered by the cellular control surfaces and the propeller drive. The control and stabilizing surfaces were combined in a cruciform tail and the forward outriggers were suppressed, the forward engine being made to drive, through a gear box and a disc clutch, a single propeller fitted at the end of the car. The performance of this experimental type was so conclusive that when the authorities required the laying down of a type embodying a larger useful load, higher speed and higher ceiling, the Zeppelin engineers decided to adopt the new propeller drive and the cruciform tail for the new ships. At the same time it was realized that the performance could still be improved by giving this type a smaller fineness (length/diameter) ratio and so it came about that the first war production type, the L.10, was only a few feet longer than the preceding type, whereas its diameter was 12 feet larger. The fineness ratio was thus reduced from 10.6 to 8.8 and the performance, owing to the better streamline of the hull, was notably improved. The outrigger propeller drive was retained for the rear car, but this now housed three engines, one of these driving a stern propeller, and another stern propeller was mounted in the forward car. When, in the summer of 1915 the new Maybach 240 hp. engine became available, it was substituted for the old 210 hp. type, resulting in a slight increase in speed of these ships.

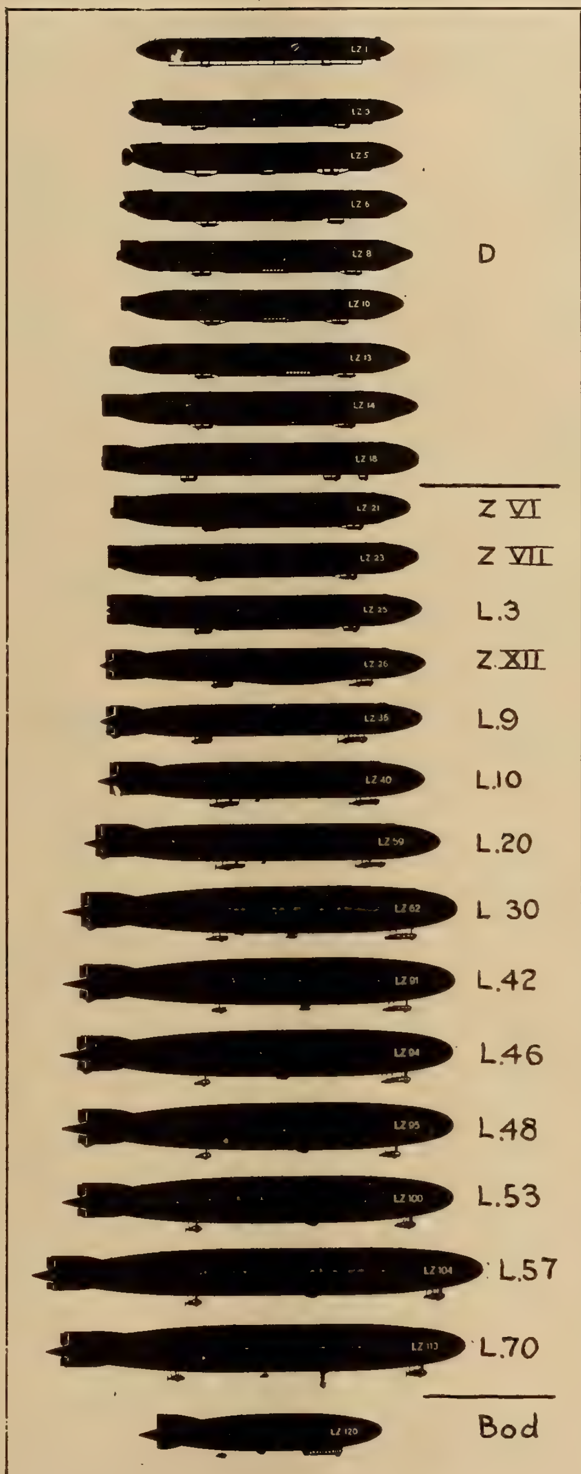
Before the close of that year a new problem came up, however. The greatly improved climbing ability of the Allied airplanes and the greater accuracy of anti-aircraft guns now made it imperative for the German airships not only to climb higher than heretofore, but also to climb faster. The naval and military authorities of Germany therefore demanded a greater margin of useful load to allow for carrying extra ballast. The Zeppelin engineers temporarily solved the problem by adding a gas cell to the L.10 type, whereby the useful load was increased by about a ton and a half. The resulting L.20 type was, however, soon to be replaced by a vastly improved vessel and when this made successful trials, the production program of the L.20 type was stopped with the sixth

vessel of the series, which was then in process of construction.

The new airship, the L.30, was the first of the so-called "super-Zeppelins"—as we referred to them during the war. In the design of this type the Zeppelin engineers once more used the familiar procedure of increasing the diameter at a greater rate than the overall length, and by so doing they reduced the fineness ratio to 8.2, producing a ship of notably clean lines. The most remarkable innovation found on the L.30 type is, aside from its huge size, the propeller drive. The power plant consisted of six 240 hp. Maybach engines which drove six propellers disposed as follows: Two astern of the main cars, two on outriggers aft, and two amidships on small "wing cars," fitted on either side of the hull, which served as engine rooms only. Owing to the head resistance of the outriggers and the interference of several propellers with one another, the performance of this heavily engined airship did not entirely come up to expectations, and steps were accordingly taken to "clean up" the design.

First the number of engines was reduced to five, the stern propeller of the after car being dispensed with together with its engine. Then, on another type, the outriggers were also suppressed so that the number of propellers was reduced to three, that is, one astern of the forward car and two on wing cars. The latter were however fitted with two engines each, either or both of which could drive the propeller through a suitable gear box and clutch arrangement. This scheme, which was intended to provide for emergencies, proved so satisfactory that the principle was incorporated in the final design of the modified L.30 (or L.48) type. In the latter there were four propellers disposed in a quadrilateral, two being in the center line and two in wing cars, and the rear main car housed two engines, one to be used for emergencies. The saving in head resistance which the suppression of the outrigger propellers represented enabled these ships to have a much better performance than the L.30 type, although their power plant was smaller. The great reluctance the Zeppelin engineers displayed in parting with the outrigger drive may be understood when it is known that this system was their own invention, whereas the wing cars had been originated by the rival Schütte-Lanz firm, which has used this drive on all of its ships ever since 1914.

The next step in improving the L.30 class consisted in generally lightening the construction. Thus the stern was deprived of its gas bag, it being deemed that the lift derived from it was out of proportion to its weight. Then, in the summer of 1917, came a much more radical innovation. The L.48 type, or L.30 type with the standard propeller drive, was entirely redesigned in detail, as a result of which the length of the gas cells was increased from 33 feet to 49 feet and their number was reduced from 18 to 14. The saving in dead weight amounted to a ton and the ceiling of the ships was improved in proportion, while maneuvering became more convenient owing to the lesser number of gas bag controls. Against this advantage was the drawback that the hull, having now two intermediate transverse girders between the main, stress-taking, frames, proved less resistant than the old design and required frequent overhauling. The introduction of a new high resistance aluminum alloy only partly solved this problem.



Courtesy, U. S. Army Air Service

SILHOUETTES OF DIFFERENT TYPES OF ZEPPELIN AIRSHIPS FROM 1900 TO 1919

Another danger against which the Zeppelin engineers had to provide in this L.53 type was the surging of the gas against the high side of the ship or against the wire wall of a gas cell that might accidentally become deflated. To provide against this contingency, which might have serious consequences owing to the large amount of gas contained in each bag—about 200,000 cubic feet in those located in the parallel portion of the hull—each gas bag was not only securely fastened to the framework by wires, but it was also internally trussed by radial wires.

Having reduced the number of gas cells in the improved L.30 type, the Zeppelin engineers were once more at liberty to increase its size for special requirements by the addition of further gas cells. Thus in the L.57 type, which was produced for special long range scouting, the capacity was increased to 2,400,000 cubic feet and the useful load to over 52 tons, with a corresponding decrease in speed and ceiling. Only two ships of this type were built, one of which made a 4,500-mile flight from Yamboli, Bulgaria, to the Soudan and return in an attempt to deliver 12 tons of medical supplies to the German forces in East Africa. Before the airship could reach its destination, however, it was recalled by a radio, the German forces in question having surrendered in the meantime. This flight is the longest non-stop voyage made by an airship to date.

In the winter of 1918 it became increasingly evident that unless the German airships could show a much better speed and climb they would, one after the other, be brought down by Allied airplanes and anti-aircraft guns. In an endeavor to solve this problem the Zeppelin engineers first fitted the L.53 type with the 290 hp., or super-compressed, Maybach type engine, and later produced the L.70 type, which was the most

heavily engined airship ever built. It had seven 290 hp. engines, four of which were mounted in wing cars, and developed a speed of over 77 m.p.h., but its ceiling was already inadequate, for British aviators brought the ship down in flames in the North Sea on one of its early raids. The sister-ships were thereupon modified by removing the reserve engine from the rear car, which increased their ceiling by 2,000 feet, and plans were laid down for the construction of a much larger series, the features of which appear in Table I. The latter, L.100 type, was ordered before the armistice, but construction had not begun when hostilities ceased.

THE SCHÜTTE-LANZ AIRSHIPS

The Schütte-Lanz airships were originally built of laminated wood girders trussed with wire stays. In appearance they were dissimilar to the Zeppelin ships in that they had streamline hulls long before the Zeppelins had them, just as they used the quadrilateral propeller drive in advance of their rivals, and originated the internal passage way. As the war progressed, however, there came a visible merging of the two designs, until finally the Schütte-Lanz Company even gave up the most distinctive feature of its design, the wooden framework. This had first been chosen because in theory it worked out at a lesser weight than the duralumin construction and because it was more easily constructed and repaired. The wooden framework would also have an amount of springiness to take up shocks with little injury such as would gravely damage a Zeppelin.

Practical experience did not fully bear out these assumptions. It is true that after several years of effort the Schütte-Lanz ships carried for the same capacity a larger useful load than the Zeppelins and that their ability to stand punishment was also greater. On the other hand the wooden framework had the serious drawback of getting out of alinement under the influence of the weather and its assembling required much more time and painstaking work than that of a Zeppelin. The want of weather-proofness of the S.L. ships explains why the German navy always looked askance at this type of construction and the manufacturers finally admitted this drawback themselves, for the S.L. 20, the last of their war series, had a framework of duralumin tubes instead of being built up of laminated wood. The experience of this firm in metal construction was too recent, however, to enable them to compete on even terms with the Zeppelin Company, which accounts for the superior performance of the latter's ships.

GERMAN NON-RIGID AIRSHIPS

Of Germany's non-rigid airships only the Parseval types deserve special mention. Although only a limited number were built owing to the acute rubber shortage Germany experienced, the later Parseval ships were remarkable for the large useful load they carried. They greatly exceeded in this respect their rigid contemporaries of the same size, but their speed was inferior. The most serious objection that came up against their use in warfare was the difficulty of keeping the envelope taut and so maintaining the shape of the hull when the ship was under way at high speed. This experience bears out the pre-war assumption that there is a limiting size beyond which it is not practical to build airships that depend on internal pressure for keeping their form, because the high internal pressure required demands a very heavy fabric—which detracts from the useful load—and also because such ships are particularly liable to mishaps owing to failing pressure.

It is interesting to note in passing that the last two Parseval airships built during the war differed from the well-known pre-war types in that a long metal girder was slung under the envelope in order better to distribute the disposable loads, such as gasoline, ballast, etc. Two wing cars were stayed to this girder amidships, while two more engine cars and a control car, forward, were suspended from it in the centerline. These large Parseval ships have thus, like the Schütte-Lanz vessels, five separate cars, which system has the advantage of removing all noise and vibration from the control car, where the radio cabin was located.

A point particularly worth mentioning is that toward the end of the war the Parseval Company started experimenting with various aluminum alloys with a view to determining whether medium size airships could not be built more economically on the rigid principle than on the pressure system. These experiments dealt in particular with duralumin tubing, which, it is said, the company intends to use in the framework of an experimental airship.

The Gross airship, M.IV, listed in Table I, was a pre-war product, having been built by the now dissolved Balloon Battalion of the Prussian army. The ship is not particularly notable, except perhaps for the fact that it affords the only record of German experiments with mooring airships to a mast, and that it belonged to the original German semi-rigid type. This was characterized by an underslung metal girder, from which two cars were suspended, a scheme which—as we have said above—was later incorporated with several improvements in the later Parseval airships. For this reason the latter were strictly speaking semi-rigid ships and not non-rigids, as the Germans called them.

TABLE II—GERMAN AIRSHIP LOSSES—1914-1918

Type of airship		Z.	S.L.	P.	M.	TOTAL	
Brought down in action	A	5	1	..	..	6	27
	N	20	..	1	..	21	
Damaged in action, wrecked on landing or foundered	A	9	..	..	..	9	15
	N	6	..	..	..	6	
Wrecked in sheds by airplane bombs	A	2	..	..	..	2	4
	N	2	..	..	..	2	
Lost in bad weather	A	4	3	..	..	7	17
	N	6	4	..	..	10	
Accidentally lost through fire	A	..	1	..	..	1	15
	N	10	3	1	..	14	
Scrapped	A	13	6	1	..	20	31
	N	6*	2	2	1**	11	
Wilfully wrecked after the Armistice	A	..	..	..	..	..	7
	N	7	..	..	..	7	
Surrendered to the Allies	A	..	..	..	..	..	7
	N	7***	..	..	..	7	
Total		97	20	5	1	123	

*Including two ex-army ships transferred to the navy.

**Ex-army ship transferred to the navy.

***Including two ex-army ships transferred to the navy, and the L.72, completed after the armistice. One of these ships, the L.37, is yet to be delivered, disassembled, to Japan.

Table II indicates Germany's airship losses during and as a result of the war. The letter Z stands for Zeppelin, S. L. for Schütte-Lanz, P. for Parseval and M. for Gross, while the letters A. and N. stand for army and navy, respectively. In the number of Zeppelin ships given there are included three former passenger airships of the Delag Line which the army authorities requisitioned on the outbreak of the war.

LIGHTING INSTALLATION FOR NIGHT FLYING

IN cases where it is necessary to indicate air routes by night, comparatively weak sources of light are adequate, and electric or gas lamps sending out intermittent beams according to some prearranged signal are suitable. The optical system should be such that the strongest rays are emitted horizontally with a gradual diminution in intensity toward the zenith.

In order to lessen the danger due to forced landings at night, it is suggested that airplanes should have a number of electric lamps attached to their main planes, so arranged as to illuminate the landing place. As the lamps would only be used at intervals and then only for short periods they might be overrun so as to give a strong light. The author suggests eight lamps to give 26,000 candle-power each.—Abstracted by *The Technical Review* from *Illustrierte Flug-Welt*, Dec. 22, 1920.

Petroleum as a Source of Soap*

Converting Non-Saponifiable Bodies into Acid Products and Then Combining with Alkali

FATTY bodies, using the word in the ordinary sense, can be divided into two groups: Those which are saponifiable and those which are non-saponifiable. The former include the oils and fats extracted from land animals and marine animals, and the vegetable oils: including those which are siccative, semi-siccative and non-siccative oils, and solid fats. To the second class belong the mineral oils, oil of turpentine, oils of tar and pitch and the essential oils.

The saponifiable fats include *one or more of the following fatty acids*: Butyric acid (butter), caproic acid (butter from the goat and the cow and cocoa butter), caprylic, palmitic, stearic, oleic, linoleic, and linolenic, combined with glycerine in the form of readily saponificable ethers.

A great many of these natural ethers of vegetable or animal origin are used in the form of food; others are employed for making soaps; and still others are utilized as lubricants or for fuel.

During the war fatty substances of all sorts were very scarce everywhere and particularly so in Germany; it was necessary to keep the larger part of the supply for food purposes, consequently the amounts usually supplied for fuel and lubrication were cut down and the soap boilers' supplies were greatly reduced. These circumstances caused much ingenuity to be expended in the effort to obtain improved methods for transforming into saponifiable fats those fatty bodies obtained from petroleum which it is impossible to transform directly into soap.

All the fatty bodies which contain fatty acids combined with glycerine in the form of ether are capable of yielding soap when treated with an alkali; in order to obtain soap from materials which are naturally non-saponifiable it is necessary to transform these neutral substances *into acid products which can be later made to combine with alkali*. All processes thus far devised have this purpose in view.

The four principal methods of attaining this object are thus stated by Moore and Egloff:

1. The halogenation of the aliphatic carbides;
2. The employment of organo-magnesian compounds (Grignard's reaction);
3. The use of naphthenic acids;
4. The direct oxidation of paraffins and olefins.

I. HALOGENATION OF ALIPHATIC CARBIDES

The aliphatic carbides are the *essential constituent portions of American petroleum*, which contain all the terms from the terms having six atoms of carbon to those containing 60 atoms. The boiling point increases in proportion to the number of carbon atoms.

It is those carbons which boil at about 300° cent. which are most frequently used, *i.e.*, those which approximate the terms $CH_3 - (CH_2)_{14} - CH_3$. If this latter group CH_3 could be transformed into the acid radical COOH we should have palmitic acid which is very abundant in all fats and oils. This first stage of the reaction can be accomplished by the action of chlorine upon the carbide.

Hence the substitution in a methyl group of a carboxyl group yields, therefore, for the hexadecane $CH_3\ (CH_2)_{14}CH_3$ palmitic acid $C_{15}H_{31}COOH$.

Chlorine may be introduced in various manners. In the process, for example, employed in the *Badische anilin u. soda Fabrik* the halogen derivatives of the paraffinic series of hydrocarbon are produced by mixing the oil and the halogen in the dark and then vaporizing the mixture by subjecting it to a silent electric charge. Others utilize the action of the ultra-violet rays. Moore and Egloff cause a mixture of chlorine and carbide vapors to which they have added a certain percentage of carbon anhydride to pass through a silent electric discharge while hot. After condensation the density of the carbide is greater and when it is treated with caustic soda it forms an emulsion, showing that there has been a formation of fatty acids.

The transformation of the halogen derivative into the fatty acid can be made by direct oxidation of the derivative or by passing through the intermediate stage of alcohol.

II. GRIGNARD'S REACTION

The Zelinski process, which is said to be capable of giving a 60 per cent yield, dates from before the war. Even then it was an accepted fact that by means of this process it was possible to produce fatty acids industrially starting from hydrocarbons, but the cost was too high for it to be undertaken.

According to this process the hydrocarbon is first treated with chlorine after which the product is dissolved in anhydrous ether and acted on by metallic magnesium in the presence of a catalyzer; a magnesium compound is formed which is treated with a current of carbonic anhydride; in this manner an addition compound is obtained which upon being decomposed by water yields an acid and an oxy-chloride of magnesium. The method is costly because of the high price of such reagents as magnesium and anhydrous ether.

III. USE OF NAPHTHENIC ACIDS

Naphthenes are carbides saturated with hydrogen like the hydrocarbons of which we have just been speaking. They form the larger part of the petroleums from Baku and Galicia in which there are also found small amounts of their oxidation products, the naphthenic acids—namely, 0.9 per cent. When petroleums are washed with alkaline lessives these acids are found in the wash water.

We owe to Pyhalla the suggestion made in 1914, that these might be transformed into soap. When they are changed into ethers of glycerine we obtain products very different from the natural substances. They form plastic masses from which artificial rubbers may be made.

IV. DIRECT OXIDATION OF PARAFFINS AND OLEFINS

This is the most direct method of synthesis and the one of most interest from a commercial point of view.

The Benedix Process.—This consists in making by means of stirring or shaking an intimate mixture of vaseline or oil of vaseline with hydrogen peroxide or alkaline water with peroxide of sodium. Oxidation slowly takes place and a fatty acid is obtained which forms a soap with the alkali employed. The operation is facilitated by adding alcohol and by heating under pressure to 80° cent.

A small amount of fatty acid was likewise obtained by Schultz by passing a rapid current of air over boiling paraffin.

According to Schmidt and Hulsberg the melted paraffin is treated for a long time by a current of air or oxygen at a temperature of 100 to 120° cent. Little by little the color acquires a reddish tint which passes into pale yellow and finally into deep yellow. In this manner it is possible to obtain fatty acids in the proportion of 70 per cent of the paraffin employed. They are accompanied by a small amount of alcohol and of formaldehyde and its homologues which are separated out by fractional distillation. The yield can be increased by the use of catalyzers such as oxide of mercury for example. By this method it appears possible to transform from 80 to 90 per cent of the paraffin into fatty acids. A very good yield can likewise be obtained by treating the paraffin with air under pres-

*Translated for the *Scientific American Monthly* from *La Nature* (Paris) for Feb. 19, 1921.

sure at a temperature of 90 to 175° cent. under the influence of ultra-violet rays and in the presence of catalyzers such as metals in a very fine state of division.

Olefins.—However, it appears to be better to make use of olefins which are non-saturated compounds that are readily oxidized instead of employing such very stable saturated compounds as the paraffins. These olefins are not very plentiful in nature, but on the other hand it is very easy to obtain them from petroleum merely by subjecting them to the process known as "cracking" (pyrogenous distillation). The following decompositions are produced in succession:

$$\begin{array}{l}\text{Paraffin}\\ C_{20}H_{42}\end{array}\left\{\begin{array}{l}\text{olefin } C_{10}H_{20}\\ \text{paraffin } C_{10}H_{22}\left\{\begin{array}{l}\text{olefin } C_5H_{10}\\ \text{paraffin } C_5H_{12}\left\{\begin{array}{l}\text{olefin } C_4H_8\\ \text{paraffin } CH_4\end{array}\right.\end{array}\right.\end{array}\right.$$

When the heating is prolonged we obtain only the gaseous and liquid products of the ethylenic and acetylenic series and the higher the cracking temperature becomes the higher is the degree of non-saturation.

Green Street Process.—In this method the mineral oils are borne by water vapor across long tubes heated to a cherry red. In this manner there are formed olefins which are oxidized and the different products are separated by distillation. The oxidation is obtained by treating first with sulphuric acid and then by the action of water upon the sulphurated derivatives. They can also be oxidized by means of permanganate of ozone or of the chromic mixture. The treatment by ozone yields ozonides which can be decomposed by water vapor to produce fatty acids. The latter can be transformed into soaps by means of alkalis or into glyceric ethers by heating with glycerine under pressure to 200° cent. in the presence of Twitchel's reagent (a sulphoaromatic compound), or under the influence of enzymes. The fatty acids obtained by synthesis can thus be transformed into higher acids by hydrogenation:

$$\underset{\text{Linoleic acid}}{C_{17}H_{31}COOH} + 2H = \underset{\text{Oleic acid}}{C_{17}H_{33}COOH} + 2H = \underset{\text{Stearic acid}}{C_{17}H_{35}COOH}$$

The Hydrogenation of Oils.—This process has been increasingly employed of recent years; it increases as we shall see the yield of concrete acids. It is in some sort a partial synthesis whose practical results are quite considerable, since it makes it possible to transform oils of an inferior commercial value into products of much more worth.

The liquid fatty substances composed of non-saturated fatty acids, namely, olein, linolein, and linolenine do not differ from the solid fats composed of stearic acid except by one or more molecules of hydrogen at least, and it is by means of a catalytic process that it has been found possible to fix the hydrogen upon the fatty acids by augmenting their fusion point and by approaching more or less closely their saturation point. Professor Sabatier of Toulouse was the first person to succeed in transmitting hydrogen to non-saturated bodies under the catalytic influence of finely divided metallic nickel. He secured this synthesis by causing a mixture of hydrogen and the vapor of the product to be treated to pass over finely divided nickel heated in a tube. But such a process can have no commercial value since most of the fatty bodies are not capable of being volatilized and decomposed at a high temperature.

The first practical achievement along this line was accomplished by Normann, who passed hydrogen into heated oil containing the catalyzer held in a suspended state by means of vigorous mechanical agitation.

The nickel forms with the oil a colloidal solution which makes it possible for the hydrogen to be absorbed and fixed in spite of its rapid passage through the mixture.

The best catalyzers for this purpose are finely divided metallic nickel, nickel oxide, and palladium. Nickel oxide is the one most often used; it is both easier to get and less fragile than pure metallic nickel itself.

Furthermore, the consumption of hydrogen is the same whatever the catalyzer employed: *i.e.*, about 100 cubic meters per ton of oil transformed into solid fat. The same amount of oil requires only 5 to 6 kg. of the nickel oxide catalyzer, whereas nearly 20 kg. of metallic nickel would be needed to produce the same result. The *industrial apparatus most commonly used* is that devised by *Wilbuschevitsch*, which consists of an autoclave in which the catalyzer is emulsified with the oil; the emulsion is reduced to a fine spray by means of a jet of hydrogen, a suitable pressure and temperature being maintained.

Five autoclaves of the same type are usually placed so as to form a series and the oil is made to circulate in such a manner that its fusion point rises 15° cent. in each container. The temperature is held at 150° cent. and the pressure at 9 kg. The catalyzer can be recovered by centrifugation or by passing the hot fat through a filter press.

The nickel oxide catalyzer is prepared as follows: A solution of pure nickel nitrate is made at 15° Baumé and washed by acids and by pure water and then dried, after which it is impregnated with some inert, porous, finely powdered substance such as Rieselgnhi. It is then treated with a solution of carbonate of soda so that carbonate of nickel is obtained; the latter is calcined to decompose it into the oxide. To obtain the metallic nickel catalyzer it is only necessary to reduce this oxide by means of a current of hydrogen at about 350° cent. and before cooling to enclose it in grease to preserve it from the action of the air.

The hydrogenation of oils is more and more made use of in industry, and there are hopeful prospects that this process, combined with that of the synthetic production of fatty acids, will make up for the scarcity of the raw materials required in soap boiling, and the stearine industry.

IS IT POSSIBLE TO OBTAIN IMAGES OF MOLECULES?

THE interesting question has been raised among scientists as to whether any method can be devised capable of producing optical images of molecules, such for example as the molecular space lattices which compose crystals according to the modern view. This question at first thought so startling is answered in the affirmative by a Swiss man of science, M. Wolfke, of Zurich, who recently read an article upon this subject before the Swiss Society of Physics. As reported in the *Archives d.Sciences phys, et Nat.* (Switzerland) for May, June, 1920, Mr. Wolfke basis his belief upon his previous researches concerning the theory of optical images, which were set forth in the *Annals der Physik* (Berlin) in 1912 (Vol. XXXIX).

His method consists in substituting for the intermediate image (primary) a photograph obtained by means of X-rays. This substitution is based upon a new theory, a demonstration of whose correctness is furnished by the author as follows:

"The diffraction image (primary) of a diffraction image (primary) of any object whatever, both of which have been obtained by means of parallel monochromatic light is identical with the image proper (secondary) of this object, provided that it have a symmetrical structure without marked differences of phase." This result has been verified by means of experiment with a number of different optical space lattices.

By this method the coördinates of the object appear to be enlarged in the ratio λ/λ' of the lengths of wave employed for the production of the new and of the first images of diffraction. By making use of X-rays to produce the first diffraction image of the object, an ordinary visible light to produce the second (the image proper of the object), it is possible to obtain in this way an enlargement of the object of the magnitude of 10,000. By the help of suitable optical systems the degree of magnitude of this enlargement of the image can be raised to several millions and this would enable us theoretically to perceive the molecules which compose the space lattices of crystals. In order to render these visible by means of this process, it is necessary always to employ the diffraction images of a single crystalline plane obtained by means of X-rays.

Science and National Progress

Edited by a Committee of the National Research Council

Dr. Vernon Kellogg, Chairman, Dr. R. M. Yerkes, H. E. Howe

SCIENTIFIC WORK IN RUSSIA OUTSIDE OF PETROGRAD AND MOSCOW*

By Sergius Oldenburg

Permanent Secretary of the Russian Academy of Sciences Since 1904

The National Research Council is a coöperative organization of the scientific men of America. It is established under the auspices of the National Academy of Sciences and its membership is largely composed of appointed representatives of the major scientific and technical societies of the country. Its purposes are the promotion of scientific research and of the application and dissemination of scientific knowledge for the benefit of the national strength and well-being.

Petrograd and Moscow are still, as in previous times, the main and basic centers of scientific work in Russia. This is quite natural since within these cities there are concentrated the principal scientific institutions of the country, higher schools and large libraries. Also the greater number of scientific workers is being trained there. However, the conditions of the present moment could not fail to have an effect on the work "in the province," as we are accustomed to say it. First of all, considerable portions of Russia were for a long time torn away from these centers by the civil war. The derangement of the transport also in a considerable measure contributed to the isolation of local centers from Petrograd and Moscow. They were forced to go ahead independently. It then appeared, as might have been expected, that many localities and cities possessed unusual vitality; they revealed great intensity in work, relying on themselves only and not looking for assistance from the outside. This was the case in some places with the older universities and higher schools, while in other parts of the country the work was carried on by former scientific societies; in still other places there formed new institutions of learning and scientific organizations.

Observing closely the life "in the provinces of contemporaneous" Russia one may note a definite tendency toward the study of regional divisions in all their relations. Consequently, there is also a tendency to create new universities, but without an adequate consideration of the local supply of instructors or that of more distant centers from which they occasionally might be obtained. No doubt, many of the regional universities are not destined to live long; even under more normal conditions the teaching personnel in the higher schools is greatly insufficient in numbers, and now, after numerous deaths and emigrations, the available teaching force is, of course, still smaller. The new universities have to reckon with an overwhelming number of vacancies or else accept a personnel not sufficiently qualified for these positions. Life, however, brings certain compensations. Some of these universities will be closed; others will be replaced by less pretentious institutions, and a certain number of them, no doubt, will maintain their rank as universities.

A great deal of vitality has been manifested by a new type of educational establishments—the Institutes of Public Instruction. These resemble somewhat the former Teachers' Institutes, but they are functioning on a more comprehensive and better basis. Among these institutes the one in Viatka met with unusual success. The Viatka region even in former times was from a cultural point of view an oasis: excellent new growth has been obtained on this old good soil. The Viatka Institute of Public Instruction began the investigation of its region with great earnestness, and its teachers have succeeded in drawing the younger generation into this work. Separate circulars dealing with the collection of data on various questions have been issued. Mention may be made of the outlines prepared by Prof. M. M. Karinski for a study of local dialects and of folklore. A small library, a memorial to Hertzen, and a local museum are aiding in this work. No doubt the Institutes of Public Instruction will prove to be a powerful factor in the cultural development of Russia, and will become that type of educational institutions now especially needed in Russia which will prepare the local workers in the varied domains of science.

The universities of Ukraine suffered most of all. They lived through numerous governmental changes and through a catastrophic reduction of teaching personnel. Years will pass, probably, before they again will be raised to a high level. A great deal was suffered also by the University of Peru. Its future is very unsettled in view of the establishment of another rural university which conforms to the new and broader principles of uniting university and polytechnicum and is more or less of the type outlined in 1917. The Ural University, just founded in Ekaterinburg, comprises a series of scientific departments. It is the second higher institution of learning in Ekaterinburg, the first being the Mining Institute. Thanks to the existence of the latter the teaching personnel for a whole series of courses is assured and also some of the necessary laboratories and equipment.

The young universities suffer most from the book famine. The University of Ekaterinburg has among its founders several very energetic men and it undoubtedly belongs to the group of live universities.

The program of 1917 had in view the establishment of three new universities: one in Caucasus, one in Turkestan and one in eastern Siberia. It was fulfilled only as regards Turkestan with a university in Tashkent and in Siberia, with a university in Irkutsk.

The young universities have succeeded in drawing a large number of students and, in spite of all the difficulties, particularly the lack of books and of scientific equipment, continue to perform their scientific work. In part, as for instance in Tashkent, this is done through invitation of specialists from the capitals. Thus, last fall Academician V. V. Barthold gave a course on the history of Central Asia which attracted not less than 500 men. The study of the Orient is being carried on at this university and at the special institute for modern oriental languages. The work is directed by M. S. Andreyev, an eminent authority on the Orient. Attention is given also to the preservation of relics of local antiquity. This is done in close coöperation with the well-known investigator and authority on Turkestan, V. L. Viatkin.

Siberia has lived through a grave civil war and in many respects life there has not yet become normal. Nevertheless, the young Irkutsk University as well as the relatively older Tomsk University are both active. The latter has already organized a series of scientific expeditions dealing with natural history and with ethnographical-archeological studies which have yielded rich scientific results.

The Geological Committee of Siberia which became a branch of the Central Geological Committee, conducted its field work all these years, even during the civil war, in spite of dangers. It may justly be proud of its remarkable achievements. The noted geologist, Y. S. Edelstein, who has just returned to

*Translated from the Russian by Michael Shapovalov.

Petrograd from Siberia, will have a detailed report in the Petrograd journal, *Science and Its Workers* on this scientific work in Siberia. An interesting investigation had been carried on also by the "Institute for the Study of Siberia," but for some unknown reasons this institution has now been closed, much to our regret.

In the Volga region the University of Saratov is especially active, the number of its students this year reaching about 5,000. Aside from its principal object the university also pursues a study of the region in all its aspects. The university youth has been drawn extensively into this work and it organizes numerous excursions either independently or under the leadership of its professors. This work also aids the growth of a good local museum. It should be noted in this connection that the museum work meets not only with a general sympathetic response in the country, but also with the support of rather wide masses of people. The objective expression of all peculiarities of a local region in a museum collection attracts every more or less "live" person and thus leads to the further accumulation of material which is not only valuable for educational purposes, but also for purely scientific interests. It is well known how much has been accomplished in this way in Finland and in the Scandinavian countries. There is one more very important phase to this affair: the creation of local specialists in one or the other sphere who can on the spot collect material or make observations throughout decades with remarkable keenness. Such persons are exceptionally valuable for the region itself and also for science. We may recall, for example, Martyanov, who was able to build up an archeological museum of world importance in the Minussin wilderness; or Pastor Billenstein who through decades of labor produced a classical contribution on wooden structures and utensils of the Letts published by the Academy of Sciences; or Pastor Hoort who collected a surprising quantity of relics illustrating the creative activity of the people; or Rudchenko who gathered material for a large volume of Ukranian fairy tales. There are many more such modest yet remarkable investigators and collectors in various places. New universities and Institutes of Public Instruction have already given their attention to them.

Very actively at work is the Northern region—the Yaroslav province and parts of the Tver and Vologda provinces with their periodical congresses. Local workers seek to harmonize their activities with the work of the central institutions and for this reason they particularly feel the effect of the typographic derangement which prevents the establishment of regular communication by means of special publications. It is, therefore, especially gratifying to note such rare exceptions as the large series of works of the Kuban Soviet on Regional Investigations with an extensive regional bibliography; the contributions from the local Kostroma society and the publications of the Museum Division in Kazan on museum matters. Irregularities in mail communications, unfortunately, prevent the systematic delivery of these contributions to the centers and in general to localities outside of the places of issue.

In the absence of an adequate system of book registry general information is lacking as to many of these publications. It is only through personal communication that one succeeds in learning more or less satisfactorily concerning the little which is being published. We have not learned as yet the vital importance of "reference books" which are maintained so admirably in the West and which are the most essential element in every organized and systematic work.

In this brief review I wished to indicate a few things which are being done for science in Russia outside of its large centers, Petrograd and Moscow. Being a convinced optimist and having a profound faith in Russia, I certainly do not close my eyes to whatever is inefficient and wrong in our present scientific work; more than once I have pointed out how scientific workers are enchained by the almost absolute impossibility to publish and how this curbs every effort. There are many other conditions interfering with the work, and yet this work is not only carried on, but we can see how new fields are being mapped out and how new intellectual forces are being awakened to activity. It also appears now as though the masses were beginning to realize that scientific work signifies more than merely idle pleasure or caprice. They appear to understand that an extensive development of science and scientific knowledge and of creative thought is the basis of the brighter future of humanity. The local scientific work has this great significance that it is being performed in the eyes of the whole population and that it affects them directly. Only when broad masses actually will have faith in science, may we be confident that no turbulence will endanger scientific work; it will then be guarded by all as the great and the most valued possession of all humanity. We hail, therefore, particularly our local workers who pursue so firmly their work—work so modest in appearance, but in reality of unusual importance; they are pursuing it in all the corners of our great country, untiringly, without folding their arms.

SCIENCE FOR THE MILLIONS

It is sixty years since since Herbert Spencer's discussion of the question "What Education Is of Most Worth?" set English speaking people to thinking as they had not thought before about the value of science and its claims to a place in popular education.

Today the problem of science in education has passed beyond the stage of debate on the general educational value of this domain of knowledge and deals with such questions as that of finding a place for science in the common school curriculum; of what particular sciences shall be taught according to circumstances; how they shall be taught, and so on.

Perhaps the master problem of all now is, How shall the great rank and file of the population be assured that minimum of natural knowledge without which prosperity and progress and happiness in the modern world are impossible?

An effort to do something toward solving this great problem has culminated in the establishment at Washington of an institution to be called "Science Service," the history of which is sketched here for the first time.

"If we must have democracy we must have a more intelligent demos." These words were spoken just as the Great War was ending in such ruin of monarchic and autocratic government and triumph of sentiment and theory at least, of popular government as had never before been seen. They were spoken by Mr. E. W. Scripps whose whole life has been devoted to building up newspaper organizations, the published matter of which reaches millions, and the labor on which is performed by thousands of the demos. The utterance delivered from such an experience had in it somewhat of misgiving about democracy. For better or for worse, democracy is inevitable. This being so, the part of wisdom is to make sure that it shall be for better and not for worse.

Now toward one conclusion experience of all peoples and all ages points unerringly: Without a highly intelligent demos, a highly good democracy is out of the question. But for this age, and this stage of world progress such a conclusion is too general. The vastness and complexity of conditions under which modern men and nations exist are such as to demand intelligence in many different fields.

The demand is not for theoretic completeness as to what intelligence ought to cover but for active effort in behalf of intelligence concerning those things and forces which are most distinctive of the times—those things which pervade it most; which are most potent in it. And what are those things? No broadly seeing, carefully thinking person who is likewise a participant in the real life of the age, can hesitate over an answer: The things and forces which are the subject matter of physical science are the ones that dominate, and overwhelmingly dominate, our era. That this is the "age of science" is acknowledged by everybody, even by many who deprecate the fact.

So the practical but likewise philosophical man whose words form our opening sentence, having reached the conviction expressed by that sentence, hesitated not at all as to the general province in which effort should be made to increase the intelligence of the demos. It should be in science. But it should be science in no paltry sense. It should not be science reduced, as in many minds it is today, to the narrow, unhumane bounds of industrial technology. It should be science more in the traditional sense—in the sense of indisputable objective knowledge of whatever kind or source.

But what agency should be used in this effort? Here is another saying of Mr. Scripps: "Whether for good or for bad; whether we like it or whether we don't, ours is an age in which 'public opinion,' control by which reaches to political government, is made by newspapers—by the daily press—more than by any other influence whatever."

The public school? Undoubtedly a mighty factor for enlightening the masses in science as in all else. But the school touches directly and potently only children and youth. *The great life-continuation school is the Press;* and so rapidly and revolutionary does new knowledge come into the modern world and new forces play upon it, that education of youth in the elements and historic deposits of learning cannot at all answer the needs of modern peoples. Life-continuation education is vital.

With such convictions; with such a business experience; and with such a structural foundation to build on, what more natural than that a project for *increasing the intelligence of demos in science by means of the journalistic press,* should be conceived?

So much for the germinal idea of Science Service. A little now concerning its coming into existence and its organization.

The very essence of adult human living and of adult intelligence forbid that any major agency for life-continuation education should be philanthropic. Serious adult education must be an essential part of real life. It cannot be a charity. It must be a part of the whole business of life and so must be on a business basis. It must pay its own way. Like any other business it must have some capital and must earn money as well as spend money; indeed, it must, finally, earn at least as much as it spends in order to be a "going concern."

But with such an aim as the contemplated educational enterprise would have, earnings for profit in the business sense would be wholly incompatible. No individual should get money from it on any basis other than that of pay for service rendered. But just as the service rendered by the enterprise to individuals or public should not be as charity, so no regular service of individuals to the enterprise should be as charity.

Self-supported public service should be the business motto of the undertaking.

With such conceptions Mr. Scripps has furnished the new enterprise a substantial initial or working capital.

Another principle laid down by the initiator of the enterprise was that because science was to be its field, professional scientists ought to be chiefly, if not wholly responsible for its creation and operation. Only through the efforts of scientific men themselves, said Mr. Scripps, would there be the least chance of success for such an experiment. Not merely their endorsement of it and sympathy for it, but their willingness to work for it, would be indispensable.

"I can do no more," he said, "than say to the scientists of the country, 'Here is the germ of an experiment in disseminating science among the people, and some money for carrying out the experiment. But the experiment itself if tried at all must necessarily be tried by you.' "

The accident, perhaps, of proximity, brought the idea thus outlined to the attention of the writer in the summer of 1919.

The matter seemed to him to contain such possibilities of good that he volunteered to bring it to the attention of the scientific men of the country as far as this could be done within the bounds of reasonable expenditure of time and effort. With this view he devoted two months during the winter of 1919-1920 to visiting a considerable number of the chief centers of scientific research of the country and holding personal and group interviews on the subject with workers in science. A total of nearly three hundred men were reached, and, to a large extent, their views obtained.

On the basis of this study it seemed justifiable to conclude that full fifty per cent of the scientific men of the United States were unqualifiedly favorable to such an experiment and were willing to help it on in such ways as they could; that some forty-five per cent were hesitant, being impressed with the importance of a wider knowledge of the results and methods of science, but also with the difficulties in the way of success in such an undertaking as that suggested; and that about five per cent were positively hostile to the idea either from conviction that it could not be carried out, or that if it could be its success would be useless if not harmful.

The conclusions thus reached warranted, it was felt, efforts toward putting the idea into execution. The consultations, conferences and correspondence had up to date contributed one particular item of enlightenment for the first positive step. No new general large organization should be made. As far as possible organizations already in existence should be utilized. A widespread feeling was manifest among scientists that organization in science was already overdone. A small corporate working body representative of existing organizations seemed the desirable thing.

But even a single representative from each scientific society, were all those of the country to be counted in, would make a body too large for the ends to be attained.

The immediate problem was, then, that of deciding what few scientific societies are most broadly inclusive of the scientific interests of the country and likewise best fitted to further the public service aims of the projected enterprise.

To deal with these and other formative stage questions, conferences of scientists and journalists were held during the spring, summer, and fall of 1920, two at Mr. Scripps's home, Miramar, California, and two in Washington, D. C. The outcome of these was the decision that The National Academy of Sciences, The American Association for the Advancement of Science, and The National Research Council were the organizations best fitted to serve as the preorganizational foundation for the new corporation, but that since the enterprise was to be vitally connected with journalism, the journalistic profession ought also to be represented.

Two important decisions as to general policy were reached by these preliminary conferences. One was that the educational work of the projected corporation need not be restricted in means to be used by the press, but might, as conditions should warrant, be extended to any instrumentalities whatever, school and college founding and operating excepted.

This enlargement of possible agencies to be used had particularly in view, though by no means exclusively so, moving pictures, lectures, and conferences.

The other decision as to policy concerned the fields of science to be included in the activities. After ample consideration it was unanimously agreed that at present "only subjects in the natural and physical sciences and their applications" shall be within the scope of the corporation's work. The aim here was to exclude the humanistic sciences which, as now conceived and, to a large extent practiced, are subject to much passionate controversy, largely because dealing with "groups of material to which precise criteria of demonstrable evidence cannot be applied."

But the main outcome of these meetings was a provisional organization consisting of six persons as follows: Dr. George E. Hale, representing The National Academy of Sciences, Dr. D. T. MacDougal, representing The American Association for the Advancement of Science, Dr. R. A. Millikan, representing The National Research Council, and Mr. E. W. Scripps, Mr. R. P. Scripps, and Dr. Wm. E. Ritter, representing E. W. Scripps Estate.

This provisional organization invited each of the three foundation scientific organizations to nominate two additional members for the final corporation, thus to make nine scientists in all from these organizations. It also provided that the E. W. Scripps Estate should have three representatives; and, finally, that the journalistic profession should be represented by three members. It being found on inquiry that the field of journalism contains no organizations comparable with the three foundational organizations in science, the provisional organization requested Mr. E. W. Scripps to nominate the three representatives from this field.

Provision was also made by the pre-corporation that as soon as the additional nominations were made, further meetings should be held for the purpose of giving the corporation its completed working form.

These final organizational meetings took place in Chicago in December, 1920, and in Washington in March, 1921.

The outcome of these was *Science Service* as it now makes its bow to the public, and declares itself to have one and only one central ambition, namely, that of serving the public in the broad sense of contributing to its welfare, and not in the technical sense of syndicating scientific "stories" for its own profit.

The initial membership of the Service follows:

Representing *The National Academy of Sciences:*

Dr. A. A. Noyes, Director, Chemical Research, California Institute of Technology, Pasadena, California.

Dr. R. A. Millikan, Professor of Physics, University of Chicago, Chicago, Illinois.

Dr. John C. Merriam, President, Carnegie Institution of Washington, Washington, D. C.

Representing *The American Association for the Advancement of Science:*

Dr. D. T. MacDougal, Director, Desert Laboratory, Carnegie Institution of Washington, Tucson, Arizona.

Dr. J. McKeen Cattell, Editor *Science* and *The Scientific Monthly*, Garrison-on-Hudson, New York.

Dr. George T. Moore, Director, Missouri Botanical Garden, St. Louis, Missouri.

Representing *The National Research Council:*

Dr. Vernon Kellogg, Permanent Secretary, National Research Council, Washington, D. C.

Dr. George E. Hale, Director, Mount Wilson Solar Observatory of the Carnegie Institution of Washington, Pasadena, California.

Dr. R. M. Yerkes, Chairman, Research Information Service, National Research Council, Washington, D. C.

Representing the *Journalistic Profession:*

Mr. Edwin F. Gay, President, *New York Evening Post Company*, New York City.

Mr. Chester H. Rowell, former editor and manager, *The Fresno Republican*, now member California Railroad Commission, Berkeley, California.

Mr. William Allen White, editor and manager *The Emporia Gazette*, Emporia, Kansas.

Representing the *E. W. Scripps Estate:*

Mr. E. W. Scripps, Miramar, California.

Mr. Robert P. Scripps, Cleveland, Ohio.

Dr. Wm. E. Ritter, Director, Scripps Institution for Biological Research of the University of Calfornia, La Jolla, California.

The funds of the corporation are not represented by stock but their legal custodianship is a board of trustees the membership of which is now coincident with the membership of the organization.

The officers of the Service are a president, vice-president, secretary and treasurer, and an Executive Committee of five, one from each foundation body, in the hands of which are placed the detailed affairs of the Service. The vice-president of the corporation is chairman of the Executve Committee.

The first officers are: President, Wm. E. Ritter; Vice-President and Chairman of the Executive Committee, Vernon Kellogg; Secretary, Edwin E. Slosson; Treasurer, Robert P. Scripps.

The Executive Committee is: Chairman, Vernon Kellogg; members, Messrs. Cattell, Gay, Merriam and Ritter.

The first vital business to be done by the corporation was to select an editor and a manager, the two work officials which, it was provided, should be the initial operative portion of the service.

After much searching and great weighing of needs and abilities, Dr. Edwin E. Slosson was chosen Editor, and Mr. Howard Wheeler, Manager.

Dr. Slosson's quite unique standing in America, as a fully accredited scientist and at the same time as a litterateur of distinction, made the final action in his favor decisive. Mr. Slosson holds a doctor's degree in Chemistry from the University of Chicago, and was twelve years Professor of Chemistry in the University of Wyoming, which position brought him into familiar terms with several other branches of science. Following this he was for seventeen years literary editor of *The Independent*, New York. During this period he devoted much time, with great conviction of the importance of the task, to writing popular science. Some of the main fruits of this period in the form of books were: "Great American Universities"; "Major Prophets of Today"; "Six Major Prophets"; "Lives of Rumford and Gibbs"; "Easy Lessons in Einstein"; and, most notable of all, "Creative Chemistry." Lectures as Associate in the School of Journalism, Columbia University, were also part of his activities in these years.

Manager Wheeler's experience on the managerial side of journalism has been quite as varied as Mr. Slosson's on the editorial side. The editor-and-managership of the *San Francisco Daily News;* managership of the Pacific Coast department of the Newspaper Enterprise Association; managing editorship of *Harper's Weekly;* managing editor and later editor of *Everybody's Magazine;* and war correspondent, constitute the inventory of his journalistic activities. He is also the author of "Are We Ready?" a pre-war book on the preparedness question of the United States.

CHEMICAL INDUSTRY IN CZECHO-SLOVAKIA

SINCE the foundation of the Czecho-Slovak Republic its chemical industries have appreciably recovered from the depression which prevailed during the war; they are well organized individually and also form part of a larger association, the Federation of Czecho-Slovak Industries at Prague. The chemical factories were mainly erected in Bohemia and Moravia, doubtless owing to the excellent transport facilities afforded by the Elbe and the Moldau. Important fertilizer plants are located at Kolin, Slany, Prerau, and Brünn, and those at Slany and Prerau also manufacture glue. Pharmaceutical products are made at Chrast, near Chrudim, and in Prague acids and explosives by the Nobel Dynamite Co. at Bratislava, and paints, varnishes, and shellac at Usti (Aussig). Mineral colors, especially ultramarine and Paris blue, chrome, and zinc colors, are made in many Bohemian towns, and coal-tar dyes are produced by the Aussig Chemical Co. at Usti, and by Kinziberger and Co. at Prague. The dye industry is not firmly established, German competition having proved too formidable in spite of a special high tariff. Ink is made by many firms, and at Ceske Budejovice (Budweis) is the famous plant of L. C. Hardtmuth, making pencils and colors. The manufacture of shoe-blacking is rapidly developing chiefly in North Bohemia. Factories producing greases, oils, essential oils, etc., are found chiefly near the large towns; before the war the production of vegetable oils, *e.g.*, linseed oil, was an important industry in Bohemia, but recently it has had to face competition from the cheaper fish and mineral oils. The soap industry has also suffered from foreign competition, and, since the war, from the liquidation of Government supplies of fats and oils; the largest factory is that of G. Schicht, near Usti, which employs more than 4,000 workers. Starch and starch-products are made almost entirely in Moravia and the adjoining parts of Bohemia.—U. S. Com. Rep., Jan. 21, 1921.

Notes on Science in America

Abstracts of Current Literature

Prepared by Edward G. Spaulding, Ph.D., L.L.D., Professor of Philosophy, Princeton University

PHYSICAL OCEANOGRAPHY

In the *Journal* of the Washington Academy of Sciences for March 19, 1921, Mr. A. L. Thuras discusses the problem of physical oceanography.

Physical oceanography, says Mr. Thuras, is that branch of oceanography which deals with such physical properties of the ocean as temperature, salinity, density, pressure, velocity and direction of water movements, for the purpose of solving the general problems of oceanic circulation.

During recent years much work of an explorational nature has been carried on in the coastal waters of the United States and Canada. Dr. Henry B. Bigelow, in coöperation with the U. S. Bureau of Fisheries, has made these investigations, and the results of his work are published in the Bulletins of the Museum of Comparative Zoology, Harvard University. Several theories of the origin and circulation of our coastal waters have been corrected, and sufficient data have been collected to give a general working knowledge of the subject. Valuable observations have also been collected by observers in Canadian waters, and from these observations some exceedingly interesting theories of ocean circulation have been developed by J. W. Sandstrom.

Since the beginning of the International Ice Patrol an opportuunty has been given to extend this work farther out into the North Atlantic in the region of the Grand Banks of Newfoundland and in the Labrador Current and Gulf Stream. The conflict of the Labrador Current and Gulf Stream south of the Newfoundland Bank causes greater changes in the physical properties of the sea water, only a few miles apart, than occur in any other part of the world. From the data obtained and the admirable current charts prepared by Captain C. E. Johnston of the Coast Guard, a fairly accurate knowledge of the movements of ice after passing Newfoundland is available.

In the spring icebergs from the shores of Greenland and Labrador are carried southward in the Labrador Current, their movement being little affected by winds on account of their small buoyance. Those bergs which are sufficiently off shore to clear the bottom and keep in the south-flowing branch of the Labrador Current are carried along the eastern edge of the Newfoundland Bank and southward toward the Gulf Stream. By measurements of temperature and salinity the course and extent of these streams can be determined, salinity generally being the most reliable indication. The temperature of the Labrador Current is —1° to + 1° C., with a salinity of 33 grams of salt per 1,000 grams of sea water; the Gulf Stream has a temperature of 15° to 20° C., with a salinity of 36. South of the Grand Bank, where the Labrador Current merges into the Gulf Stream, a large area of mixed water is formed, and at this place the Labrador Current ceases as an individual current. In this mixed water almost all the icebergs remain until they melt, and, as this area is usually very foggy from the mixing of the warm and cold waters, it becomes extremely dangerous for vessels. At no time during the last four years has an iceberg ever been located in the unmixed waters of the Gulf Stream, which have a salinity of 36 and a temperature above 15° C.

A comparison of the yearly observations show that the volume and strength of the Labrador Current have a decided influence on the course of the Gulf Stream in this vicinity. In some years the Gulf Stream was found almost up to the southern end of the Grand Bank, in other years as far south as the 40th degree of north latitude, a variation of over 100 miles. This variation in the deflecting power of the Labrador Current must have an effect on the volume of flow of the Gulf Stream to the eastward and also possibly west of this position.

In order to obtain a clearer and more complete understanding of the dynamics of ocean circulation, an effort has been made in recent years to develop recording instruments. Hans Pettersson of Göteborg, Sweden, has built a photographic recording current meter which will give a continuous record of current velocity and direction for a period of two weeks. By the use of special anchors and buoys the instrument can be firmly anchored at any depth up to several hundred meters. Dr. R. A. Daly of Harvard University has recently constructed a thermograph which can be used at great depths in the ocean, and which will give a continuous record of temperature for a week or more. The U. S. Coast Guard in conjunction with the Bureau of Standards has designed and constructed a recording salinity apparatus and a recording thermometer which will give continuous records of temperature, salinity and density of the sea water taken from intake pipes below the surface by a moving vessel.

The physical oceanographic observations collected in our Atlantic waters indicate that that stage in development has been reached which calls for more thorough plans of work extending over a long period of time. These investigations can be accomplished most successfully by international coöperation, development of physical oceanographic instruments, and establishment of a permanent oceanographic laboratory.

THE MOVEMENT OF ROCK MASSES

Within the zone accessible to observation movements of rock masses are accomplished by fracture and flowage. These processes may be distinct and separate, or so interrelated as to make definition difficult. The zones of movement are many, their positions and attitudes diverse. In general they indicate shearing or grinding movements between rock masses, accomplished both by fracture and flowage, and caused by stresses inclined to the zones of movement. This conception is taken to afford the best initial basis for the interpretation and correlation of observed rock structures. There is no certain evidence of increase or decrease of movement toward the bottom of this zone. Beyond a shallow surface zone, there is no certain evidence of increase of rock flowage and decrease of rock fracture with depth. There is no certain evidence in rock flowage that pressures are dominantly hydrostatic or dominantly those of competent solid bodies.

Movements are known to occur in the zone below our range of observation, but their nature and distribution are the subjects of varied hypotheses based on a few known conditions. Much of the sharper diastrophism seems to be confined to a thin surficial zone. Deeper movements, of a more passive type, periodic and possibly slower, seem to be implied by the relative movement of great earth segments as represented by continents and ocean basins. Their depth is unknown. Most of the current hypotheses agree in assuming a single mobile zone in which rocks move dominantly by rock flowage. The basic requirements of reasonable hypothesis, however, may be equally well met by a conception of movement much like that of the zone of observation. This does not require or postulate the conception of the existence of any single mobile zone, or zone of slipping, or zone of flowage, or of an asthenosphere. It supposes movement irregularly distributed in many zones, with any inclination, and accomplished by both fracture and flowage as far below the surface as movement extends—always remembering that some of the structures geologically described as fractures, may be expressions of mass movement of the kind defined as flow in experimental results.

Conditions of temperature and pressure and vulcanism become more intense with depth, but it remains to be shown that their conjoint action results in a uniform environment, and even if it does, that this condition is not upset by what might be called a heterogeneity of the time factor as represented by differing rates of deformation. If homogeneous environmental and time conditions are assumed, it is yet to be shown that these are sufficient to overcome the heterogeneity of the physical properties of the rocks and to cause homogeneous behavior through any considerable zone. It is not even certain that they may not fix and accentuate the heterogeneous properties of rocks. Certainly in the zone of observation there is comparatively slight evidence of their efficacy in causing more uniform deformation with depth.

In short, as between alternative conception as to the conditions in the deep zone, the burden of producing affirmative evidence would seem to rest heavily on any conception involving radical departure from the known irregular distribution and manner of movement within our zone of observation. We come, therefore, to the conception of a heterogeneous structural behavior of the earth.—Abstract from article by Dr. C. K. Leith of the University of Wisconsin, *Science*, March 4, 1921.

THE PRACTICAL VALUE OF ANTHROPOLOGY

IN an important article in *Science* for February 18, 1921, Prof. A. E. Jenks discusses the Practical Value of Anthropology for the nation.

Stated broadly the bed-rock national anthropological problem, says the author, is the survival and improvement of the human element of our nation. The *sine qua non* of civilization at any time is man's survival on physical, intellectual, and moral planes as high as those he possessed at that time. Civilization is lost to the extent that man's survival-planes are lowered. The goal of civilization seems to be for increasing numbers of mankind to survive on more elevated planes of mutual, physical, intellectual and moral freedom. It appears to be a part of cosmic evolution for each generation to press toward that goal. But to a large extent even today our generation is pressing blindly toward this goal with its mind on remedial factors rather than on causative factors.

Ethnic groups differ one from another. They differ beneath the skin. We know, for example, that the processes of pigment metabolism are so unerring and persistent that patches of skin taken from one person and grafted on another take on the proportion of pigmentation natural to the "stock" or seat on which the transplanted skin lives. We know also that ethnic differences are so much more than only "skin deep" that ovaries transplanted from one person to another person would reproduce children of their own kind without influence by the person who served as "stock" or seat for the transplanted ovaries. There are, it must be granted, no experiments of this sort, but what has been proved true with other animals would without question be true of human animals. Thus there is scientific reason to speak of different "breeds" of people whose differing physical characteristics are today due to the factors resident in the reproductive germ cells. Ethnic differences are not simply "skin deep." They are germinal. They begin at the functional innermost center of the person, and they continue through to the outside. The man who runs sees the outside differences between breeds of people. The anthropologist knows they begin inside in the seeds of the breeds.

The American immigration problem is centered in the various breeds of people who are clamoring to come to our shores or who are already in our midst. What facts and tendencies of strength and weakness for the future of the American nation are in those various ethnic groups? On the answer to this question hinges the whole immigration problem. It is a question for the most careful study, the accumulation of accurate data, and for effort at scientific conclusions on the part of anthropologists in order that an intelligent public opinion based on known facts, instead of sentiment or prejudice or commercial profits for the few, may dictate our policies and practise in regard to the people coming to us or already here.

THE ORIGIN OF THE MECHANISM OF HEREDITY

DR. MERLE C. COULTER of the University of Chicago presents in the *Botanical Gazette* for December, 1920, an important discussion of the problem of the Origin of the Mechanism of Heredity.

It seems safe to assume, says Dr. Coulter, that the most primitive organism lacked not only an organized nucleus, but even the components of a nucleus. A consideration of the activities of such an organism will, however, reveal a suggestion as to the origin of the hereditary mechanism.

The metabolism of this primitive organism, in certain fundamental features, will be similar to that of all organisms. Raw materials will be taken in and transformed to provide building materials and energy. If the raw materials be pure and the machinery of the protoplast perfect, this transformation will be complete, so that all the raw materials taken in will be transformed and used. Actually, however, the raw materials provided are never quite pure, and the machinery of the protoplast, although infinitely more efficient than any man-made machine, must be subject to certain flaws and frictions of its own. The transformation and use of materials, therefore, will not be complete; certain waste materials and *by-products* will remain. It is now the fate of the by-products which is significant.

Certain of the by-products may be insignificant in their influence upon the protoplast. Others will undoubtedly be toxic in their effect, as many investigations upon auto-intoxication have gone to show. Primitive excretory systems, developed primarily for the disposal of waste materials, may remove a considerable part of these by-products. Thorough cleansing of the protoplast by this method, however, is impossible. Inevitably by-products will accumulate with the age of the organism. In fact age itself, in other than the purely chronological sense, is probably accounted for by this very accumulation of by-products. The toxic influence of these by-products will interfere with the efficient working of the machinery of the protoplast, and metabolism will be slowed down; hence "old age." Rejuvenescence occurs with cell division, because at cell division the protoplast is cleansed of many of these toxic by-products. This cleansing probably involves both physical and chemical forces. Physical reorganization at cell division will explain the exposure of these by-products; chemical oxidation will account for their removal (as toxins).

Again, were the machinery of this cleansing process a perfect one, rejuvenescence would be complete. Actually, however, the cleansing of the protoplast at cell division is not (or is not always) absolutely thorough. A few of the by-products pass over to the daughter protoplasts. The daughters, therefore, start life with a few by-products which the mother did not possess at the beginning of her life. Since these by-products are toxic and impair or retard metabolism, it is evident that the daughters are, at birth, slightly "older" than was the mother.

A series of repetitions of this performance through successive generations will have a cumulative effect. As a consequence, not only does the individual grow old through ontogeny, but, in a very real sense, the whole race is gradually aging through phylogeny. Evidence is not lacking that the higher organisms, cell for cell, have a lower rate of metabolism than do the more primitive ones. This is a statement of the quantitative effect of these by-products. It is their qualitative effect, however, that casts light upon the origin of the hereditary mechanism.

The by-products which originally accumulated in the protoplast were of various types. Some were very toxic and these, if they were not immediately eliminated, resulted in the death of the organism. Others were less toxic, relatively more harmonious with the protoplast itself. These last, since they were

not immediately fatal, stimulated an adaptive response on the part of the protoplast.

As to the general nature of this adaptive response, an important assumption must be made. Recent researches upon mammals have revealed in these organisms the power to develop antitoxins. This power is probably one of the fundamental characteristics of all protoplasm, being present even in the most primitive organisms.

Certain by-products in the primitive organism, only slightly toxic in their effect, stimulated it to produce an antibody. The antibody counteracted the influence of the toxic by-product by insulating it from contact with the protoplast. Antibodies were probably developed most successfully for those by-products which were the least toxic in their effect. These by-products then became insulated by the antibodies. This insulation was significant not only in cutting off the influence of the by-product upon the protoplast, but in another respect also. At cell division this by-product, even though exposed, is not oxidized because of the protection afforded by the antibody which insulates it. It is probably this mechanism, for the most part, which accounts for the fact that some of the by-products are passed on to the daughter protoplasts, as mentioned before. *These by-products are the primitive bearers of hereditary characters.*

This theory accounts for the origin of the hereditary mechanism in terms of by-products and antibodies which insulate them. These various antibodies must form an important constituent of "modern" chromosomes, but there must also be present some more stable and homogeneous framework.

The origin of a given by-product is accounted for by chance environmental conditions. The environment referred to may well have been the external environment in the case of the simpler organism, but must be the internal environment in the more complex. This seems also to provide sufficient basis to explain the small degree of inheritance of acquired characters.

Research Work of the United States Bureau of Standards

Notes Specially Prepared for the SCIENTIFIC AMERICAN MONTHLY

THE FIRE RESISTANCE OF BUILDING MATERIALS

One of the most interesting sights which may be witnessed at the Bureau of Standards is in connection with the investigation of the fire resistance of various building materials. Moreover, this work is of the greatest possible importance and should go a long way toward improving building construction. Believing that in order to reach sound conclusions in investigational work, it is necessary to duplicate conditions met with in actual service, the Bureau has constructed apparatus by means of which it is possible to subject a full sized wall to the intense heat existing during a conflagration.

In order to accomplish this end a furnace has been constructed, closed by permanent walls on three sides, while the fourth side is made up of a removable steel framework like a large picture frame within which may be constructed a panel or wall of the material to be tested. The dimensions of the panel which may be erected within this frame are 16 feet long by 11 feet high. The entire framework containing the panel may be moved by a suitable crane so as to admit of easy access to the interior of the furnace. At the base of the furnace are two burners supplied with fuel oil and air by means of regulating valves and a motor-driven blower. Temperatures at different points within the furnace and in the wall or panel are measured by thermocouples so that the degree of heat attained after a given length of time in different portions of the material being tested may be easily observed. The usual way in which one of these tests is conducted is as follows: Suppose a brick panel is to be investigated; the wall is built up within the steel framework using the desired bricks and mortar and with an average quality of workmanship so as to insure conditions similar to those met with in service. The wall is then allowed to stand for several weeks in order to insure the evaporation of moisture. After this period is over, the fire test is carried out. The framework with the brick panel is placed in position so as to close up the furnace, the fuel and air turned on, and the temperatures recorded after definite periods. Usually the panel is subjected to the fire test for a definite length of time, say, 6 hours, and if it does not break down before the expiration of the period, the framework containing the panel is removed from the furnace to permit examination of the side exposed to the fire. The maximum temperature attained in the furnace may reach 2,000 or 3,000° F., but with a wall of good construction the temperature of its exterior surface should be below that of most combustible materials. Fusing and cracking of the material, warping due to expansion, etc., are all taken into account in determining the value of the wall as a fire-resisting medium.

A test of this sort is being conducted approximately each week at the Bureau and the whole will form an elaborate study of fire resistance which should prove of the greatest value to builders and architects.

A NOVEL TYPE OF BOLT

Recently one of the government departments requested the Bureau to investigate various means for fastening two heavy steel plates together in a situation where ordinary bolts and rivets could not be used. Two means were suggested for accomplishing this object: one was by inserting a pin which under normal conditions would have a diameter slightly in excess of the holes in the plates and which by some means could be contracted sufficiently to enter the holes; while in the other a pin or bolt was to be used having drilled along its axis a small hole in which an explosive charge could be inserted, the idea being that the bolt would be an easy fit in the plates and would afterward be expanded by the explosion of the charge.

Practical experiments using both means for accomplishing the object were tried at the Bureau of Standards. The first method tried was by the use of liquid air; the pins were about 0.001 inch too large for the holes and were immersed in liquid air until they could be driven into the plates rather easily. As the pins warmed up they became a tight fit. When the strength of the joints thus secured was determined in the Bureau's testing machines, it was found that it would meet the requirements. In the second method, that using the explosive charge, a strength almost as great was obtained.

The practical application of these methods, of course, may not prove as satisfactory as has been indicated in the tests, but it is of considerable interest in any event.

A CAUSE OF AIRPLANE ENGINE FAILURES AND DISASTERS

Unquestionably a snow storm may cause a plane to crash. The assertion that a plane may come to grief from a snow storm of which it itself is the cause is, nevertheless, startling. Recent experiments at the Bureau of Standards have shown such an occurrence to be by no means impossible. This snow storm, however, is not one that is seen by the pilot, but one that takes place in the intake manifold of the engine.

Since the altitude laboratory makes possible the testing of airplane engines under service conditions, it is to be expected that many of the troubles occurring in service will be experienced in these tests. Laboratory tests offer exceptional opportunities for tracing such troubles to their origin, because under such conditions so many more quantities are measured than in service. This instance furnishes an excellent illustration.

During some of the Bureau's investigations, when the existence of trouble became apparent from a decrease in engine power, measurements showed the rate of air flow to have decreased as would have been the case had the drop in power been occasioned by closing the throttle. Tests in the carburetor test plant had shown that such a throttle action might be produced by the formation and collection of snow in the induction system. The snow itself had been observed through a glass section of this system. Snow thus appeared a very probable source of the difficulty.

To form snow, two conditions must be met: (a) Moisture must be present and (b) the temperature must be low enough to freeze this moisture. Indirectly, both of these conditions may be satisfied by the vaporization of fuel in the inlet system. This vaporization requires heat, much of which is supplied by the mixture. As a consequence, under certain conditions, the temperature will drop below the freezing point. A decrease in temperature decreases the weight of water vapor that a unit volume of air can contain and the surplus condenses. Hence, the temperature drop produced by the vaporization of the fuel may result both in the condensation of moisture and lowering the temperature to the freezing point of water, and hence satisfy both conditions necessary for the formation of snow.

Actual proof that snow was the source of trouble was not hard to obtain. The test equipment is so arranged that the air passes over heating grids on its way to the engine. Increasing the air temperature 20° C. or more by this method cured the trouble in every instance. The set-up also permits the air for the engine to be taken over refrigerating coils, thus being cooled to a temperature so low that it can contain almost no moisture. This air is then reheated to the desired temperature. It was found that air so treated permitted satisfactory engine operation at those temperatures where trouble was encountered with the air from which the moisture had not been removed.

It will be readily appreciated that the starting point of this trouble is the drop in temperature brought about by the vaporization of the fuel. The cure obviously is to supply sufficient external heating to prevent this temperature drop. How much external heating is necessary to attain this end can be calculated from knowledge of the heat of vaporization of the fuel.

The chief danger from this source is not that it causes a decrease in power, but that it results in violent fluctuations of power which can neither be predicted nor controlled by the pilot. These fluctuations are produced when fragments of the snow are dislodged and result in changes of speed similar to those produced by suddenly opening the throttle. Moreover, if such trouble is instrumental in causing disaster to the plane, the snow will all melt before the engine can be torn down for examination. There is then left nothing to substantiate the pilot's report of engine trouble.

There is an unfortunate tendency to attribute all accidents for which no satisfactory explanation can be found to the fault of the pilot. It is believed that the above information will explain some of these disasters for which pilots have been unjustly blamed.

PARTIAL IMMERSION THERMOMETERS

Most of the thermometers made and sold for laboratory use in this country have been of the so-called total immersion type, that is, they were pointed and graduated to read as nearly as feasible correct temperatures when immersed so that the bulb and the whole of the mercury column were at the same temperature. It is only in rare cases, however, that thermometers, especially those used at high temperatures, are immrsed more than a few inches. Under such conditions the thermometers read too low, and a so-called stem correction should be applied. However, the proportion of those engaged in chemical or similar work in this country, who are both able and willing to go to the trouble of calculating and applying such stem corrections, is perhaps 1 in 10,000. It is, therefore, in general preferable that partial immersion thermometers should be used in ordinary laboratory work. This year for the first time the General Supply Committee has specified partial immersion thermometers for general use in government laboratories and the American Chemical Society's committee on Guaranteed Reagents and Standard Apparatus has recommended the use of the same specifications which were prepared by the Bureau of Standards. A note on total and partial immersion thermometers in which the advantages and disadvantages of the two classes of thermometers are set forth has been published in the *Journal of Industrial and Engineering Chemistry* for March, 1921.

SMOKE MASKS FOR USE OF THE DISTRICT OF COLUMBIA'S FIRE DEPARTMENT

A request was received from the District of Columbia Fire Department to assist the Chief Engineer in the preparation of specifications for smoke masks and in training the men in their use. A special "smoke house" is being equipped for this purpose. Conferences with the Chief Engineer have been held and plans for the work have been made. The characteristics of different types of masks have been discussed in relation to requirements for fire fighting and comparative tests on them will soon be made. Valuable advice on the smoke aspect and the illuminating gas aspect of this question has been obtained from two specialists in these subjects who were connected with the Chemical Warfare Service during the war.

RECENT CHEMICAL PUBLICATIONS

"The Determination of Iron by the Cupferron Method" by G. E. F. Lundell will appear in the April number of the *Journal of the American Chemical Society.*

"The Determination of Cobalt and Nickel in Cobalt Steels" by G. E. F. Lundell and J. I. Hoffman has been accepted by the *Journal of Industrial and Engineering Chemistry.*

NATIONAL ELECTRICAL SAFETY CODE

Handbook No. 3 of the Bureau of Standards has recently been published and may be obtained from the Superintendent of Documents at 40 cents per copy. This new addition is a book of pocket size and the discussion of the rules has been segregated in a separate volume which will appear later as Handbook No. 4.

In addition to two introductory sections giving definitions of terms and rules for the grounding of apparatus and circuits, the Code consists of four principal parts as follows:

(1) Rules for the installation of machinery, switchboards, and wiring in central stations and substations; (2) rules for the construction of overhead and underground lines for the transmission and distribution of electrical energy and intelligence; (3) rules for the installation of electrical apparatus and wiring in factories, residences, and wherever electricity is utilized for light, heat, or power; (4) rules for safeguarding employees when working near electrical machines or lines.

This code has been developed with the coöperation of all interests concerned. It has been thoroughly revised for this edition and many of the rules have been made mandatory in several states. Their use will, no doubt, be greatly extended now that the new edition of the code is available; they are being used voluntarily by a large number of utility companies.

Progress in the Field of Applied Chemistry

Notes Culled from Current Technical Literature

By H. E. Howe, Member of American Chemical Society

INFLUENCE OF COPPER UPON THE SOLUBILITY OF IRON

Bell and Patrick in the March Journal of the American Chemical Society discuss the results of their experiments on "The Influence of Copper on the Rate of Solution of Iron in Acids." There has been much debate upon the effect of the presence of the small amount of copper in iron as regards the corrosion of that material. For example one experimenter reported that two-tenths of a per cent of copper materially decreased the corrosion of steel sheets under atmospheric conditions, while another declares that many investigators have deceived themselves in concluding that so small a percentage of copper makes steel more resistive. The present authors undertook a study of the rate of solution in hydrochloric and sulfuric acids of various concentration and prepared alloys containing one-tenth %, three-tenths %, five-tenths %, one % and five % of copper. Due to the slowness with which dilute acids attack alloys of this type the experiments were conducted with concentrated acids and this was necessary since the method employed involved measurement of the rate of gas evolved due to the reaction between the acids and the metals. The rate of solution of pure electrolytic iron and pure reduced iron were compared with that of the copper alloys and under the conditions of the experiment the alloys showed a definite decrease in solution.

ASSAY OF COAL FOR CARBONIZATION PURPOSES

A new laboratory method for the assay of coal for carbonization purposes is the subject of Technical Paper No. 1, Fuel Research Board, Department of Scientific and Industrial Research, Great Britain. For some time there has been need for a method of coal analysis in which by direct weighings and measurements the yields of gas, oil, water and carbonaceous residue resulting from the carbonization of coal at definite temperatures could be quickly and accurately determined. Some laboratories have practised the distillation of samples of coal on a small scale and while no new scientific principles are involved in the new method reported, still, a standardization has been obtained by means of which coals can be classified with a precision not heretofore possible.

The apparatus consists of a glass retort which resembles a distillation tube in which a charge of coal of 15 grams is placed. This small retort is connected to a Leibig bulb which acts as a condenser for the reception of the liquid products, a tube filled with glass beads and sulfuric acid for the absorption of ammonia, and a gas holder connected with a reservoir counterbalanced so that as the gas enters displaced liquid passes into the reservoir, thus maintaining automatically a constant pressure in the holder.

The electric furnace which the retort has heated is mounted upon rollers so that the charged tube may be placed in position with great ease after the furnace has been heated to 300° C. As soon as the evolution of gas occluded by the coal and of expanded air stops the temperature of the furnace is gradually raised so that the ultimate temperature of 550 to 600° C. is reached in one hour. During this period observations are made of the temperatures at which water and oil appear. Heating at the final temperature is continued for an hour at the end of which time the rate of gas evolution has fallen so that further heating gives a practically negligible addition to the volume.

The yield of coke is obtained by weighing the hard glass retort tube with its contents. The Leibig bulb shows the yield of water and oil by its increased weight and the volume of the aqueous portion is measured by washing the contents into a 10 cc. graduated cylinder 8 with chloroform or petroleum ether. The contents of the sulfuric acid tube are mixed with the aqueous washings from the Leibig bulb and distilled to give the yield of ammonia and bases. The gas volume is easily ascertained.

Checks upon coal assayed by various methods indicate that the sample method can be accepted as a satisfactory means of testing coal for carbonization. The paper gives tables of results as well as drawings of the apparatus and full directions for the use of the method.

GLUE ANALYSIS

The March number of the *Chemical Bulletin* in the series of guides to analyses gives a discussion by Charles R. McKee on the interpretation of glue analysis. The following is quoted:

"*Viscosity* and *Jelly Strength* have been discussed in the various texts and journals and are used as a main guide in determining the quality of the glue. By comparing standards or type samples with the one under investigation the relative grade can be determined. The oil viscosimeters on the market are not adapted to glue testing due to the shallowness of the well, lack of uniformity of orifice in different instruments of the same make, lack of provision to replace the orifice tips in case of injury or corrosion, and also poor means of release of the liquor which occurs in some types. As a result nearly every glue manufacturer has devised his own instruments for determining viscosity and jelly strength, resulting in instruments of various degrees of success and of individual standards.

"The *foam test* is determined by stirring in some mechanical manner with the minimum loss of temperature, noting the volume and timing the duration of the foam. This has relation to the glue's behavior in mechanical spreading machines.

"*Keeping Quality.*—Glue is a nitrogenous material which easily serves as a culture medium for bacteria. Liquefying bacteria can cause a serious loss of quality in a short time and if cleanliness is not maintained by the user this loss can be carried forward from day to day by contamination. Many glue manufacturers add a small amount of antiseptic or disinfectant to their glues to avoid bacterial invasion. Where a glue liquor is held some time it is of interest to know how well the liquor will keep. This is determined by maintaining a sample of the liquor at 98° F. and noting the number of hours the glue remains 'sweet.' The addition of a suitable germicide by the user does not injure the quality when applied in reasonable quantity, but is not encouraged because it admits carelessness and slovenly methods, and also risks the use of injurious disinfectants.

"*Grease.*—Glue is a good emulsifier and may carry over grease in the process of manufacture. Grease in limited amounts is desirable in some work and again is objectionable in others; for example, it is undesirable in water paints and glass chipping. It can be determined quantitatively by careful hydrolysis with acid, mixing the residue with sand and extracting.

"*Nitrogen* is determined when a non-nitrogenous adulterant, such as dextrine, is believed to be present, or to determine the percentage of glue in a composition. The nitrogen determination is not a guide to grade.

"*Ash* is determined to detect adulteration or faulty manufacture. However, adulteration of this kind is rare.

"*Sulphur and Sulphides* are looked for when the glue is used for silverware wrappings (sizing) or containers.

"The following are not of great value as standards, be-

cause of the personal equation, skill required, influencing factors, or even absence of merit.

"*Joint Test.*—Within reasonable limits all good grades of glue will give a glue joint stronger than the wood itself, providing that the joint has been carefully made. In other words the joint test will reflect the condition of the wood, the contact of the surfaces and the manipulation.

"The success of many glue salesmen lies largely in their ability to understand the three above conditions, and if possible, supplying a glue to meet them.

"The *color* and *thickness* of a flake of glue are of little value in determining the grade.

"The *fracture* of a piece of glue is claimed to indicate quality but much experience is required to appreciate this. Moisture influences the fracture to a marked extent, so that little confidence can be placed on this test.

"The *shape* of the pieces of glue is no measure of its value. For example, 'noodle glue' has not special merit.

"*Streak.*—Some consider glue good when it forms a white streak on bending; it is needless to say that almost any glue will streak if it has enough moisture.

"*Finger Test (Jelly).*—Perhaps the test that the glue maker takes the most personal pride in is his ability to tell the quality by the feel and firmness of a congealed sample. In fact, by continuous practice he does develop skill in judging but has no method of expressing the value in units.

"*Glass Chipping.*—The novice in this art will have a difficult time duplicating results as this work requires skill and standard conditions of drying. This test indicates nothing excepting that the glue is adapted to chipping glass.

"*Film Test.*—The casting of sheets on glass, stripping and drying is apt to lead to erroneous conclusions unless all factors of temperature, thickness, stirring, rate of drying and humidity are constant.

"*Brush Test.*—Pigment on dye is mixed with glue liquor and the mixture is brushed out on paper. This is supposed to indicate the amount of grease present in the glue, as the globules of grease will prevent the color to adhere in spots. The extent of spotting will depend on the character of the grease present and the state of division of the particles. Some glues are so greasy that the dry particles adhere together, yet they will not spot the paper. However this test is of value to makers of some types of cold water paints."

A COMPARATIVE STUDY OF VIBRATION ABSORBERS

The March number of the *Journal of Industrial and Engineering Chemistry* contains an interesting report of a study of vibration absorbers by H. C. Howard. All those concerned with the use of such sensitive apparatus as an analytical balance have been confronted with the problem of so mounting as to eliminate vibration which at times is so serious as to make results of no value. By the use of a kymograph the actual vibrations have been recorded, using the various devices which have been suggested for the elimination of vibration, these including air bags inflated to various pressures, rubber balls filled with air at forty pounds pressure, and various arrangements of these balls. These arrangements include balls held between strips of wood, two sets of balls separated by a frame, a series of three balls one above the other held in position by a section of pipe supported at its base by a flange and four balls piled in tetrahedral form, the three base balls being retained in place by a triangular wooden frame. Further, slabs of sponge rubber built up to a four-inch thickness were tried as well as those of cork and of felt.

It has always been held that some type of suspension involving a heavy frame work and considerable space and expense is the only satisfactory method for the elimination of vibration and it was with a view to learning whether a satisfactory substitute could be secured that these experiments were carried out. Of the various substitutes the tetrahedral arrangement of the rubber balls gives the best results although the spring suspension is markedly superior to any of the supporting devices developed. Such a suspension does have considerable vertical vibration and when the suspension and tetrahedron are used in combination considerable improvement is obtained.

THE ACID PROCESS APPLIED TO TANNERY WASTE

E. S. Dorr in a recent issue of *Public Works* discussed the Miles acid process applied to tannery waste. The sample submitted to the process was very high-colored and heavily charged with organic and mineral matter, which contained 4,886 parts mineral matter per million parts and 1,583 parts organic and volatile matter. Upon the application of sulphur dioxide the waste cleared quickly and settled well within half an hour. The black red color was changed to straw when 860 parts of sulphur dioxide per million were used and sterility could probably have been secured with 900 parts. The odor was completely eliminated and the reduction of organic and volatile matters including suspended solids was fifty per cent. The precipitated sludge amounted to 4 tons dry weight per million gallons of waste treated and with grease content of 16.88 per cent, ammonia 7.5 per cent, and in the degreased sludge the ammonia was 9 per cent. Expressed in pounds, there was recovered 1,644 pounds of degreased fertilizer material and 1,360 pounds of grease per million gallons of waste.

The values of the products have been estimated at from 291 to 331 dollars per million gallons treated and the cost for the treatment would amount to $161.22. The disposal of tannery waste has been a source of great concern and as far as the literature shows there has been no revenue from such waste heretofore. In addition, the fact that the sludge and the effluent are inodorous and that the color is so bleached that with reasonable dilution there would be nothing noticeable except at the outlet, and that the sterility in the effluent can be obtained, would seem to recommend further experiment with tannery wastes treated by the process in question.

DECORATION OF PORCELAIN

In the *Pottery Gazette*, H. Banard discusses the decoration of porcelain and the article is abstracted as follows from the *Journal of the American Ceramic Society*:

"True oriental porcelain is fired in the first firing only sufficiently to enable it to be handled and the hard firing takes place during the glost firing. In the case of hard porcelain and common stoneware the body and glaze are fired in one operation whereas soft porcelain, china, English bone china, and earthenware undergo two firings. Motor-driven polishing lathes are used to remove blemishes from glazed ware due to stilt marks, etc. Underglaze colors when examined under the microscope appear as fine powder. In printing a copper plate is engraved with a pattern which is then covered with an underglaze color. The surplus color is rubbed off. A piece of tissue paper sized with a water size is spread over this plate and the color is pressed on to the paper with a lithographer's press. The design is then transferred to the bisque ware which is then passed through a hardening-on kiln where it is fired just sufficiently to harden the color. The glaze is then put on and it is fired in a glost kiln. Overglaze colors are a mass of glass with metallic oxides differing from underglaze colors which contain no flux. For enamel colors certain metals may be used. Gold gives a pink and manganese gives an amethyst. Copper with a high soda glass gives turquoise and with a high lead glass, bottle green. The best gold decorations are made by grinding metallic gold with mercury. A flux of glass is used with the gold to make it adhere more firmly. In acid gold decoration the pattern is put on white glazed china with an oily acid resisting paint. The piece is then plunged in an HF bath where all exposed portions are partly etched by the acid. The paint is then removed and gold decorations applied all over the ware. After firing the piece is burnished, whereupon the pattern appears bright and the etched portion dull. Ground laying is a process by which an even coating of color is applied on ware in

whatever space is desired. For example a green vase with white panels is made as follows: The shape of the panels is painted on with resist-color—anything that will resist oil—which may be a mixture of treacle and color. A very sticky oil, such as boiled linseed, is then applied over the pot. Green enamel is then dusted on, there is just sufficient oil to take a certain amount of enamel and no more, thus producing an even tone. The pot is then immersed in water which removes the treacle and color but not the oil and enamel."

FUTURE DEVELOPMENTS OF THEORETICAL CHEMISTRY

This was the subject of an address by Dr. Irving Langmuir on the occasion of the tenth birthday of the Chemists' Club, and those interested in new aspects of science are urged to read the address in full as it appears in the March 30th number of *Chemical and Metallurgical Engineering*. The discussion marks an important advance in theoretical chemistry and considers the possibility of reasoning out properties of as yet undiscovered elements and compounds and their reactions as based upon the structure of the individual atom. Dr. Langmuir points out the properties of chemical molecules which have been predicted by those unfamiliar with chemistry on the basis of certain fundamental principles regarding the stability of certain electrons. On this point the following is quoted from the address:

"I found a good deal of skepticism among these physicists as to what really could be done from such simple assumptions, until finally I proposed to one of the members who was most active in the discussion or criticism of the theory—in a constructive way, however—that he should answer the question himself as to what a physicist could deduce in regard to the properties: I therefore asked him what compounds there would be between hydrogen and lithium, and if he could tell me what the properties of that substance would be, if there is such a substance. He replied that he had no knowledge of any compounds of lithium and hydrogen; but by applying the fundamental idea that a pair of electrons around a nucleus will form a very stable configuration, and also by using his knowledge of Coulomb's law and other well-known electrical laws he was able in a very few minutes to derive these conclusions: That lithium hydride should have a formula LiH; that it should be a white crystalline solid body under ordinary conditions, a non-conductor of electricity when solid, but if molten should conduct electricity electrolytically, and hydrogen should appear at the anode, which is not where hydrogen usually appears. Now many of the properties of lithium hydride were not known until recently; but G. N. Lewis predicted those facts in regard to the electrolytic conductivity of lithium hydride, and only recently, within six months or so, Professor Nernst has had published an article on electrolytic conductivity of lithium hydride, showing that the hydrogen is liberated at the anode instead of at the cathode. Those were predicted in this case by a physicist who had never heard of lithium hydride, and doubted very much whether such a thing existed."

CHEMICAL RESEARCHES IN DYESTUFF APPLICATION

The following interesting announcement from the *Color Trade Journal* for March is quoted in order that those desiring to devote their efforts to researches in the dye field may become familiar with the present needs:

"The Society of Dyers and Colorists have a fund which is devoted to the development of chemical research in fields related to the application of dyestuffs. Below is given a list of proposed researches for which as yet no investigators have been nominated, and the Council of the Society is willing to make grants varying from £25 to £200 to competent investigators who are willing to undertake any of these researches.

"(1) The dyeing of kemps in woolen yarn or pieces;

"(2) The dyeing of a black on cotton yarn to stand a chlorine bleach, and to be fast to rubbing, at a cost not exceeding that of an ordinary aniline black;

"(3) The dyeing of dead cotton present in cotton yarn or piece goods;

"(4) An exhaustive study of the Foulard dyed style (tannin, caustic discharge, fix in tartar emetic, and dye in basics), with clear indication as to how the various difficulties can be overcome to insure regularity on the commercial scale.

"(5) A scientific investigation of the process of mordanting cotton cloth with aluminate of soda for full alizarin red;

"(6) A cheap and efficient means of fixing pigment colors in printing so that they shall stand boiling soap (see Manby's patent);

"(7) A practical method for the production of fast multicolor prints in combination with print-on indigo (glucose method);

"(8) A method of producing a yellow discharge on dyed indigo similar to that obtained with Leucotrop O, but fast to washing and light;

"(9) White and colored discharges on sulfide colors;

"(10) Colored resists, including red under aniline black, fast to strong soaping;

"(11) An investigation into the influence of the various finishing agents upon the resulting fastness to light of dyed leathers;

"(12) A method of application of sulfide dyestuffs in the dyeing of vegetable, chrome, and oil dressed leathers;

"(13) A method of manufacturing on a small scale a fat liquor emulsion, using any desired oil or fatty matter, without the employment of soap, sulfonated oil, or egg yolk as emulsifying agents;

"(14) A satisfactory method for the fixation of acid colors on cotton;

"(15) The production of a green by coupling with beta-naphthol, which can be worked similarly to and in conjunction with para red;

"(16) An investigation into the cause of tendering that occurs during the lime boiling of cotton cloth, both in open and closed kiers;

"(17) A method of obtaining complete penetration of dye through thick leather, preferably employing acid dyestuffs, the leather to be dyed the same shade throughout.

"(18) The maximum amount of iron, ammonia, bichromates, sulfuric acid, and similar products that can be employed in the dyeing of various vegetable tanned leathers without having a detrimental action. Also the cause of the detrimental action these products produce;

"(19) Possibility of the production of a combination of synthetic tan and dyestuff to be used in one operation;

"(20) Scientific study of the ageing of iron mordants for production of dark shades in dyeing."

DETECTING LEAKING GAS

Considerable loss of life and property has resulted from the leakage of the distribution in natural gas and blue water gas used for fuel and illumination. The Bureau of Mines, therefore, undertook investigations looking to the employment of stenches to be added to the gas particularly in the case of blue water gas which is almost colorless and particularly dangerous, being poisonous due to the presence of nearly 35 per cent of carbon monoxide.

Leaks in pipes, particularly those in the open, are seldom detected until the loss of gas becomes appreciable and even then the leaks are difficult to find.

Technical Paper No. 267 of the Bureau of Mines has been issued and includes a description of an odorimeter which has been devised in order that the intensity of stenches may be measured and also gives in detail the chemical, physical, and physiological properties of chemicals which may be used as stenches. In summarizing the result of the investigation these statements are made:

"The impregnation of natural gas or blue water gas with a stench-imparting chemical provides a means for reducing loss from leakage and for eliminating accidental poisoning and

explosions. Measurements of the intensities of odors have been used to ascertain the quantities of stenches needed to impart a strong odor to gas and to calculate the costs. Use of the strong odor is advised. Stenches that possess a disagreeable odor serve best as warnings. Of those examined, amyl thioether, ethyl mercaptan, phenyl isocyanide, and pyridine present the best possibilities with regard to the cost of impregnation, as well as to other properties required.

"Gas can be uniformly impregnated with a stench by allowing it, when cleaned and still warm, to pass through a horizontal pipe into which stench liquid is delivered at a uniform rate. Gravity feed of the liquid can be used, but requires more supervision than mechanical appliances, such as engine lubricators. The lubricator manufactured by the Richardson Phoenix Co., of Milwaukee, Wis., is well adapted for gas impregnation. Gas can be impregnated by placing in the pipe at regular intervals a quantity of stench and allowing the natural mixing of gas in the gasometer to make a uniform concentration.

"None of the stenches that contain sulphur, if added to gas in amounts to produce strong odors, would carry sufficient sulphur to inhibit commercial use of the gas. The maximum addition of sulphur is 8.0 grains per hundred cubic feet of gas, imparted by ethyl mercaptan."

Research Work of the U. S. Forest Products Laboratory

Notes Specially Prepared for the Scientific American Monthly

LAMINATED BASEBALL BATS

THE usual method of making baseball bats is to turn them down from solid squares of wood. Tests made by the Forest Products Laboratory at Madison, Wisconsin, have demonstrated conclusively that they can be made just as well out of thinner pieces of wood glued together, and then turned to shape.

Laminated bats turned out at the laboratory were put to use in baseball games during two seasons and proved highly satisfactory. Occasionally a bat broke in service, just as solid bats do, but in every case the break was due to failure of the wood and not to glue failure. Some players showed a preference for the laminated bats and used them at every opportunity; others were prejudiced against them. This was no doubt due in a large measure to the balance or "feel" of individual bats, which is perhaps the most important item to the player.

In the opinion of a well-known baseball coach, the laminated bats drove the ball just as well as the solid bats and were as good in all other respects. It seems thoroughly demonstrated, therefore, that to relieve a shortage of stock of the proper quality and size in ash and other suitable woods, baseball bats can just as well be made of thinner material glued together.

CHEMICAL REACTION AFFECTS CASEIN GLUE

ALTHOUGH casein glues are highly water-resistant, they ultimately decompose when exposed to a damp atmosphere for a long time. For many months studies have been under way at the Forest Products Laboratory to discover the cause of this decomposition.

The decomposition study is still far from complete, but the conclusion has been reached that the decomposition of ordinary alkaline casein glues is not due to the action of bacteria or molds. It appears to be due entirely to chemical action of the alkali in the glue. This conclusion is based upon the following observations:

Increasing the amount of alkali in the glue increases the rate of decomposition when the glue is kept wet.

Glues containing no sodium hydroxide, although deficient in some important respects, do not decompose as rapidly as similar glues containing sodium hydroxide.

Cultures of molds and bacteria could not be obtained from decomposed alkaline glues.

Some chemicals which have antiseptic properties are found to improve casein glue, but this improvement is due to their chemical action rather than to their toxic properties.

Glues can be completely decomposed in a short time at temperatures above that at which bacteria can grow.

Further work is being directed toward the production of glues which will resist chemical decomposition and at the same time be impervious to the action of fungi and bacteria as well as moisture.

SPLIT POSTS AND ROUND POSTS

Is A split fence post as durable as a round fence post? This is a question frequently asked of the U. S. Forest Products Laboratory. The fact is, one kind of post will last about as long as the other if the amount of heartwood is the same in both. But if the percentage of sapwood is increased by splitting the split post will be less durable, and if the percentage of heartwood is increased it will be more durable than a round one. Posts of spruce, hemlock, or any of the true firs are exceptions to this rule, because their heartwood and sapwood are about equally durable.

When posts are to be treated with creosote or other preservative, a round post is preferable to a split post, because of the comparative ease with which the sapwood can be treated. The heart faces on split posts do not, as a rule, absorb preservative well. Split red oak posts will take treatment because the wood is very porous, but the heart faces of split posts of many other species, notably white oak, red gum, and Douglas fir, resist the penetration of preservative, even under heavy pressure.

EFFECT OF KILN DRYING ON WOOD-BORERS

A NEW advantage of kiln drying over air drying which the Forest Products Laboratory has discovered is that kiln drying is fatal to some, if not all, wood-boring grubs. This fact is of considerable importance to users of ash, hickory, and many other woods which are attacked by insects. Manufacturers using ash lumber, for instance, are much annoyed by the injury worked by the red-headed ash borer. Air seasoning has no effect on the activities of the grubs, but, according to test made by the laboratory on wood infested with them, any kiln-drying process which can be considered practical for seasoning ash of any thickness will put an end to the borers.

TO STOP DOORS FROM SHRINKING AND SWELLING

THE fact that the top and bottom edges of a door are practically always left unfinished is largely responsible for their troublesome habit of swelling and shrinking. The exposed ends of the vertical stiles give the most bother, because wood picks up or gives off moisture more rapidly through surfaces cut across the grain than through those cut parallel to the grain.

If the doors in a house are to shut easily and fit tightly it is important that their top and bottom edges be protected by paint or varnish. If it is necessary to refit the door after it is hung, the freshly exposed surface should be refinished at once.

Survey of Progress in Mechanical Engineering

Prepared Under the Auspices of the American Society of Mechanical Engineers

INDUSTRIES AND SUPERPOWER

By Harold Goodwin, Jr.

The cost of fuel and purchase of power for all the industries in the United States amounts to only about 2½ per cent of the value of the products and is only about 4½ per cent of the value of the materials going into these products. (These figures apply to the country at large and not to individual industries.) Nevertheless, the subject of power generation and distribution is, of course, of the highest importance.

As regards the determination of the future load Dr. George Otis Smith, Director of the U. S. Geological Survey, has pointed out that the steam engine has been the cause of centralization of industry, while electricity has already been the means of decentralization and the greatest mission of the superpower system should be the aiding of industry in its economic decentralization.

Chart, Fig. 1, shows the method of determining the limit of saturation of industries with power. The upper curve shows the growth of the total mechanical power and the growth which may be predicted for it in the future, while the next curve shows the proportion of the load which could be economically supplied by central station service. The lower curve shows the growth of central station power and the way its logarithmic extension would continue. It is evident that the limit of central station supply of mechanical power should be

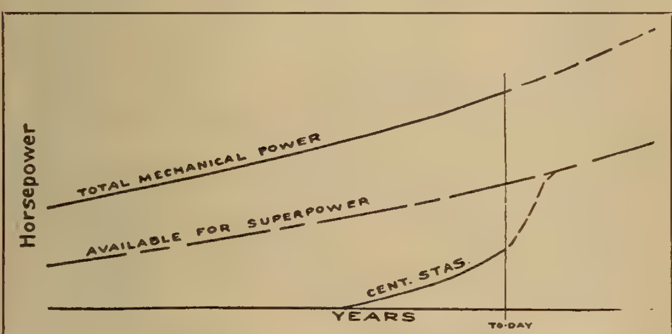


FIG. 1. GROWTH OF INDUSTRIAL MECHANICAL POWER

reached if the present rate of growth is maintained for a few years and that after the point of saturation has been reached the growth will be much more gradual.

This consideration would show that it is not safe to predict the load of the superpower system simply by the extension of the present growth curve of central stations.

The location of industries is determined by many factors, such as labor, transportation, raw material supply, etc. In some cases there seems to be a tendency for industry to move to the nearest supply of labor; while in others plants have made arrangements for drawing labor to them instead of carrying the plant to the labor. Availability of power through the superpower scheme may be of assistance in facilitating the location of plants on sites otherwise desirable. If there is a tendency of industry to decentralize, availability of power will be one of the controlling factors in the building up of new industrial centers.—*The Journal of the Engineers' Club of Philadelphia*, Vol. 38-2, No. 194, Feb., 1921, pp. 63-68.

CENTRIFUGALLY CAST STEEL PIPE

By George K. Burgess

Abstract of a report of tests carried out by the author, in 1918, at the Bureau of Standards, on samples from hollow steel cylinders made by the W. H. Millspaugh process.

No data as to the process itself are given, except that the cylinders were cast in a machine revolving about its horizontal axis. The cylinders are said to have walls from ½ to 3½ inches thick. The outer surfaces were fairly smooth but the interior surfaces were rough. Plain carbon and nickel steel castings were investigated in the condition as cast and after various heat treatments.

Results of the radial surveys for hardness and chemical analysis show there is a gradual increase in carbon from the outside to the inside surface for all castings. This increase ranges from 0.02 to 0.09 per cent and appears to be roughly proportional to the carbon content, so that the percentage in variations remains practically constant. The nickel and phosphorus appear to follow the carbon very closely in their behavior as to segregation; manganese and silicon, on the other hand, are nearly constant across the radial sections, while sulphur, although somewhat erratic, in general, is distributed similarly to carbon.

The hardness surveys follow closely the chemical segregation, the higher numbers occurring on the inside layers. Stresses across section of tubes were measured by cutting out rings and it would appear that the internal stresses are of the order of the elastic limits of the material, the outer zone of the casting being in compression and the inside ring in tension.

Various attempts were made to improve these castings by heat treatment, the data being given in the form of tables. Most samples show good tensile strength for their composition and treatment and there does not appear to be any marked difference in values for longitudinal and transverse specimens.

Certain of these treated steel castings would appear to compare favorably with those of forged material of the same composition. For example the physical properties of some of the castings are equal to or better than ordnance requirements for gun forgings.

The only evidence of unsoundness of the metal was the presence of small blowholes in the inner zone, usually within 1/16 inch of the surface.

The microstructure of some, at least of these castings, is better than that of ordinary castings; certain ones show pronounced ingotisms (dendritic structure). The nickel steels contain more slag inclusions than is usual in ordnance steel, showing that this centrifugal process may not clear up a basic steel. The ingotism and coarse-grained structures of these centrifugal castings can, in general, only be removed by prolonged and repeated heat treatments, *i.e.*, normalizing followed by double quench and draw.—*The Iron Age*, Vol. 107, No. 12, March 24, 1921, pp. 764-766.

(*In this connection attention is called to an editorial in the same issue, p. 789, discussing centrifugal casting of steel as a metallurgical development which may become of importance.*—Editor.)

MANUFACTURE OF WROUGHT PIPE FOR HIGH PRESSURES

For hydraulic purposes very strong pipe is required because the high pressures of hydraulic lines exert enormous bursting forces and the potential energy of the water under such working pressures closely approaches that of the thrust of a steel rod working as a piston under similar pressure.

The pipe must therefore be made with unusual care and furthermore to be efficient in the face of the friction developed by fluid flowing under enormous pressures and high velocities the pipe must be clean and smooth and must be capable of

bending without excessive distortion of the internal diameter. These conditions require that the pipe be welded and rolled according to the best mill practice and that the metal possess the usual combination of high tensile strength and great ductility.

The following practice is followed by the National Tube Company, Pittsburgh, Pa.:

To make pipe for hydraulic purposes, the solid ingot is rolled down to plates of the required dimensions which eliminates laminations occurring in plates rolled from built-up bars, and insures homogeneity of the pipe wall. Defects such as blister or blowholes are obviated in the skelp from which pipe is made by a mechanical process of working the metal in bloom form, known as Spellerizing. It is a kneading process which consists of subjecting the heated bloom to the action of rolls having regularly shaped projections on their working surfaces.

High-pressure pipe of smaller sizes is manufactured by the butt-welding process. The hot plate is welded into pipe at a point close to the end of the furnace by drawing through it a die shaped like a bell with a hole in one end. The pipe is reheated several times and drawn through dies having gradually decreasing diameters until the proper size is obtained. This is done in order to weld thoroughly the very thick abutting edges of the seam and to provide the necessary strength at this point.

When pipe is not intended for high-pressure service it is drawn through only one or two dies.

The larger sizes of pipe for high-pressure purposes are made by a process in which the edges of the plate are overlapped by the seam. The plates are properly rolled, heated and bent into rough tubes (skelp) and are then charged into a furnace where they are heated to a welding temperature. From the furnace they go into the revolving rolls of the welding apparatus, so grooved that they form a circular opening between them of approximately the same size as the outside diameter of the pipe. In this opening is a bullet-shaped mandrel and as a skelp comes from the furnace it is caught by the rolls which force it forward over the mandrel and press the overlapping edges together into a sound weld.

To make one length of the strong pipe used for certain purposes, two lengths of pipe are welded in this manner and then telescoped, this being arranged in such a way that the welds of the telescope pipes are at diametrically opposite points. In this position they are reheated to a welding temperature and are both passed at once through the welding rolls, thus forging them into a single length of heavy-walled pipes.

After the pipe has been welded it is passed through rolls which give it the required outside diameter and through cross rolls to straighten it and give it its true circular shape. The pipe is then slowly cooled on a continuously traveling table, after which the tags and the ends which have become damaged in manufacturing are trimmed off and the pipe is subjected to a hydraulic test to prove the soundness of wall and weld. The test pressures vary from 700 to 3,000 pounds per square inch according to pipe size and type of weld.—*Machinery*, Vol. 27, No. 8, April, 1921, pp. 755-756.

MICHELL CRANKLESS STEAM ENGINE

DESCRIPTION of a high-speed steam engine designed by A. G. M. Michell, inventor of the Michell thrust block for the purpose of testing whether by the use of these blocks it was practicable to construct crankless internal-combustion or steam engines, which would presumably be lighter than engines of conventional type.

In the Michell engine the crank is replaced by a swash plate which is not new in itself, but has not been done successfully in the past owing in the main to lubrication difficulties.

As the Michell bearings are good for a load of at least 500 lb. per sq. in. and have been used under loads many times greater, it was believed that they would help to get rid of the greatest difficulty heretofore experienced in substituting a swash plate for a crankshaft.

Fig. 2 shows the first such an engine. It comprises 8 cylinders, each 5 in. in diameter, arranged 4 on each side of the swash plate A, which is keyed to the driving shaft of the engine, which in its turn carries at each end a rotary valve B controlling the admission of steam to the cylinders. The engine works on the uniflow principle, the exhaust being discharged through ports C, of which there are eight for each cylinder, each $1\frac{1}{8}$ inches in diameter.

The pistons on opposite sides of the swash plate are rigidly connected in pairs to form a single unit, the weight of the unit being adjusted to that of the swash plate so as to secure perfect running balance. (Formula given in the original article.)

The thrust of the pistons is transferred to the swash plate

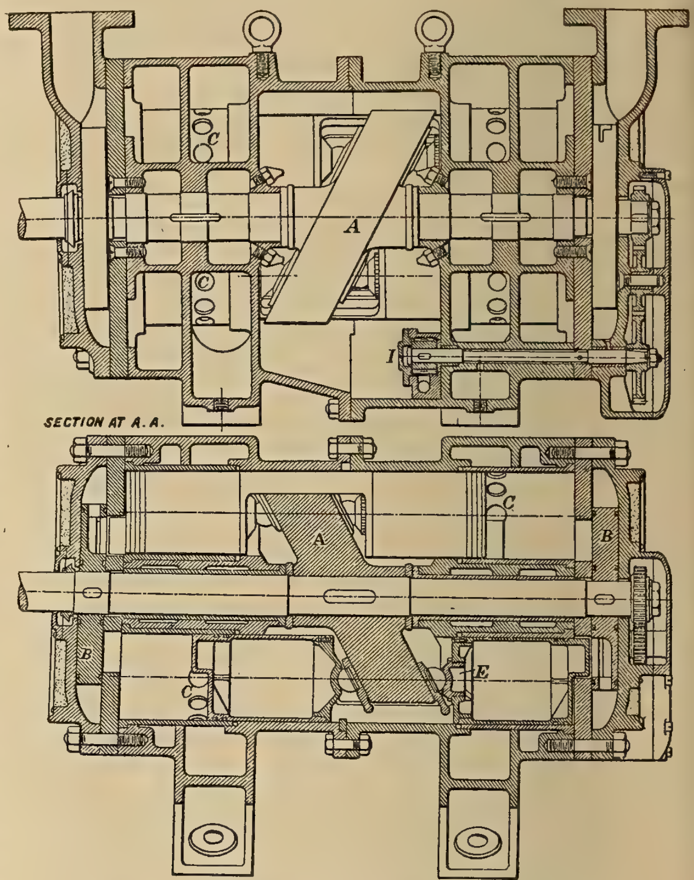


FIG. 2. MICHELL CRANKLESS STEAM ENGINE

through Michell blocks which are mounted on spherical seats and an ample supply of oil is maintained by means of a gear-driven pump.

Provision is made for adjusting the distance between the Michell blocks on opposite sides of the swash plates as at E. To the end in view one of the ball sockets is mounted on a screwed sleeve which can be adjusted by turning it by the notched head.

The engine was designed to run at 1,200 r.p.m. but the tests have shown that this limit can be greatly exceeded. In the tests the steam was supplied at 150-lb. gage pressure and exhausted to a condenser in which a vacuum of 26 inches was maintained.

The swash plate was held at an angle of $27\frac{1}{2}$ degrees, but Mr. Michell intends to reduce this in future engines to $22\frac{1}{2}$ degrees, since the tests showed that the larger angle was unnecessary. The horsepower developed was 0.92 i.hp. per cylinder per 100 revolutions, and it is believed the engine can be run at speeds up to 1,500 revolutions.—*Engineering*, Vol. 111. No, 2880, March 11, 1921, pp. 290-291.

Progress in the Field of Electricity

Summaries and Excerpts from Current Periodicals

By A. Slobod

ELECTRIC DRIVE OF SHIPS

THE entire issue of the *General Electric Review* for February, 1921, is devoted to the subject of electricity on board ship. The question of electric propulsion is discussed by many prominent engineers. Mr. W. L. Emmet who has probably devoted more attention to this problem than any other engineer states that the applications of the system to naval vessels have given results in exact agreement with predictions, and a very large demand has been created for electric transmission equipments. The reasons why the General Electric Company has adopted this method of driving ships are that investigations have shown them that if the conditions of reversing and other matters are correctly allowed for, the electric drive gives a transmission efficiency practically equal to that of mechanical gears in their best condition, while it also greatly simplifies the turbine, saves space in ships, eliminates long lines of shafting, minimizes the risk of breakdowns, and facilitates the work involved in carrying out repairs.

The question of efficiency is quite important, and this is treated in a paper by Mr. Eskil Berg. The efficiency of conservatively designed double-reduction gearing, according to Mr. Berg, is about 94.5 per cent, and the loss incidental to the reversing turbine about 1.76 per cent, making a total loss of 7.26 per cent. There is also a loss in the reversing turbine itself due to the large clearances and to the fact that the reversing elements make the turbine longer, which necessitates a larger shaft and greater leakage loss between diaphragms as well as increased packing and bearing losses, and to this should be added the power taken by the various oil pumps required for lubrication. If for any reason the turbine is divided into high- and low-pressure parts, there are additional packing losses and a loss arising from the transfer of steam from one casing to the other, which may amount to 2 or 3 per cent. Taking a typical electrically-propelled ship of 3,000 shaft horsepower and with a shaft speed of 100 revolutions per minute, Mr. Berg fixes the motor efficiency at 95.65 per cent, including excitation, and that of the generator at 96.3 per cent, and allowing .04 per cent loss in the cable, the total loss is estimated at 7.93 per cent against 7.26 per cent for gearing. While it is admitted that there are many geared turbines running satisfactorily, it is asserted that a considerable number have given a great deal of trouble, and, on the whole, the writer is firmly of opinion that electric transmission is very frequently superior to gearing. It is of course well appreciated that it is on war vessels that the electric drive shows up to the best advantage. Economy at widely varying speeds is not nearly so valuable in the case of merchant ships; nevertheless other advantages of the electric drive are prompting its application to merchant vessels.

The closing months of 1920 gave birth to this innovation in the turbine electric drive of the merchant ships "Eclipse" and "Cuba." Some details are given by Mr. E. C. Sanders:

The "Eclipse" is a cargo vessel, the first of twelve vessels of the United States Shipping Board to be equipped with electric propulsion machinery. She is 440 feet long, 56 feet beam and of 11,868 dead weight tons. The propulsion machinery consists of a turbine direct connected to an alternating current generator which supplies power to an induction motor that is direct connected to the propeller shaft. A complete description of the control of the propulsion machinery is given in the article of R. Stearns in the same February issue of the *General Electric Review*. The performance of this initial installation on a cargo boat is gratifying. On November 9, 1920, the "Eclipse" sailed from New York for the Dutch East Indies and, after crossing the Atlantic in two days less than the regular schedule time, reported that all the equipment was operating satisfactorily and that the captain found great improvement in handling the ship in storm and in maneuverng in port.

The passenger ship "Cuba" is 320 feet long, 40 feet beam, and has a displacement of 3,580 tons. The principal difference between the propulsion machinery of this vessel and that of the "Eclipse" lies in the use of a synchronous motor instead of an induction motor for driving the propeller, with corresponding differences in the control equipment. On the official trial trip of this boat the propeller was brought from full speed ahead to a dead stop in two and one-half seconds and to full speed astern in seven and one-half seconds additional. The rapidity of this reversal brought the speed of the vessel from full speed to a dead stop in 140 seconds, which is considered remarkable in view of the fact that from four to ten minutes are required to stop the corresponding reciprocating engine-driven ship.

While up to the present nothing of a serious nature has happened to the early installations of the "Jupiter" or of the battleship "New Mexico," yet in the design of the latest alternators fitted to electrically-propelled vessels special precautions have been taken to protect the windings in the event of short circuits causing fire, and heating coils are fitted to prevent the accumulation of moisture on the windings when the machines are not in service. In the event of an internal short circuit occurring—which is said to be a very rare occurrence indeed—the ventilation damper is closed, and steam is admitted to the windings through perforated pipes fitted to the end shields, by which the fire is extinguished instantaneously. With these latest refinements and with a reasonable amount of care, the electrical installation is claimed to be practically immune from a complete breakdown which would leave the vessel stranded at sea. It is also shown in an article written by A. P. Badgley that in the case of induction motors some faults will not result in a complete breakdown if the machines are operated under the right conditions.

The Diesel engine electric propulsion is discussed by Mr. W. H. Wild, who gives its advantages and details of the first vessel so propelled—the "Mariner."

ELECTRIC FIRES

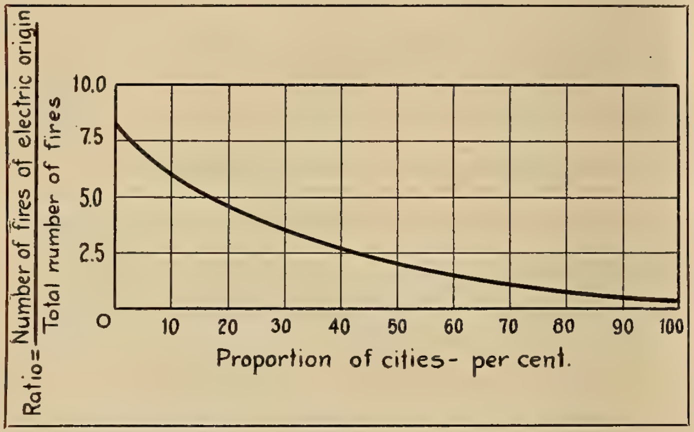
A GRAVE misconception concerning the number of fires attributable to electricity has been caused in the past five years by the widespread publicity given to the statistical compilations of fire losses by the National Board of Fire Underwriters. Electricity has been advertised, quite erroneously, as the most general cause of fires, the inference being that it is the chief fire hazard—the reason for the abnormally high annual fire loss in the United States—outranking even carelessness in smoking and in the use of matches which is given as the second hazard of importance, chargeable with a very considerably smaller loss than that due to fires of electrical origin.

The fallacy of placing any such interpretation on the records of the Fire Underwriters is made apparent by the exhaustive investigation which has been carried on by the Society for Electrical Development to ascertain the facts concerning fires which occurred in the year 1919 in communities supplied with electric service. Reports from 345 cities show that 138,553 fires occurred in 1919 of which those apparently of electrical origin numbered 3,568, establishing a mean fire ratio for fires of electrical origin of 2.57 per cent. This percentage differs sufficiently from the inferred electric fire ratio of the Fire Underwriters' report—about 6 per cent—and from the

even larger ratios frequently advanced to demonstrate forcibly the danger of accepting records compiled for special interests.

The discrepancy between the figures of the Fire Underwriters and those of the Society of Electrical Development is due entirely to method of approach and objective of the two investigations. The compilation of the Underwriters consists primarily of records of adjustments made on some 3,500,000 claims for damages occasioned by fires to which is added an arbitrary 25 per cent to cover unrecorded fires. It is essentially a record of private interests and consequently must be biased to a greater or less extent. The investigation of the society, on the other hand, has been based upon investigated reports submitted by fire chiefs, department, municipal and state officials, central station records and statements from special commissions in a very large proportion of the country supplied with electric service in 1919. These reports were investigated as carefully as possible to discover the full number of fires attributable to electricity and to eliminate from the records such fires as could be proved to be wrongly classified as of electrical origin and those which are known to have been confined to street cars, automobiles, poles, transformers, generators and motors and which did not therefore in any way affect property of private ownership.

As so many factors affect the prevalence of both the total number of fires and the number of fires of electrical origin which may occur in a given community, it has been found



MASTER CURVE OF FIRE RATIOS FOR ALL CITIES
62 per cent have fire ratios below 2.57 and about 90 per cent below 6

that the study of individual cities is of greatest value. The city of Chicago, for instance, reported through its acting fire marshal that in 1919 there were 14,407 fires, 562 of which were of electrical origin. This would give an electric fire ratio of 3.9 per cent which in view of Chicago's enormous electric load, might not be considered excessive. However, a careful investigation of all fire records made jointly by the engineers of the Commonwealth Edison Company and the city department of gas and electricity established the fact that the total number of fires known to have been of electrical origin was only 116. Even this relatively small number proved an over-estimate upon further investigation, as sixteen of the so-called fires turned out to be simply cases of motors or generators being burned out without other damage and six were due to short circuits occurring in automobiles on account of chafed tires. Thus, the total number of fires in Chicago attribuatable to the use of electricity was not more than 94—probably less—giving the city an electric fire ratio of 0.65 per cent.

NEW PRESERVATIVE FOR WOODEN POLES

This preservative was invented by Malenkovic. It consists of 88.89 parts of sodium fluoride and 11.11 parts of dinitrophenolaniline (by weight). Comparative tests have been made of the durability of wooden telegraph poles impregnated with copper sulphate and of similar poles impregnated with this new preservative. The poles were treated under pressure with a 2.4 per cent solution of basilit in water till the wood had absorbed about 3 kg. of basilit per cubic meter. A statistical survey covering the performance of 4,000 poles during the years 1913-1917 indicated a spoilage percentage of zero in the first year, 0.09 in the second year and 0.12 in the third and fourth years, giving a total loss of 0.33 per cent for the four years. Similar poles impregnated with copper sulphate according to the Boucherie method and used under similar conditions during the same years showed a spoilage of respectively 0.11, 0.75, 3.26 and 6.23 per cent, or a total of 10.35 per cent poles in the four first years, which is thirty-one times as much as the corresponding figure for the basilit-impregnated poles.—Nowotny, *Elektrotechnik und Maschinenbau*, November 21, 1920.

X-RAY EXAMINATION OF MATERIALS

A very interesting review of the recent application of X-rays is given in a paper of Mr. J. R. Clarke contributed to *Beama* for February, 1921. The author first reviews the fundamental principles underlying the X-ray apparatus and then discusses the production of X-rays. There are three sources of high voltage available, namely, influence machines, induction coils and transformers. The influence machine has been found unreliable and is very little used. After discussing at length the advantages and disadvantages of the induction coil and the transformer the author comes to the conclusion that if the X-ray installation is required for the continuous examination of heavy materials a transformer is preferable, but if light materials are to be examined, or heavy materials only occasionally, an induction coil will do the work.

The history of the other essential for the production of X-rays, the vacuum tube, is then briefly traced; the famous Coolidge tube is then described in detail and its advantages enumerated as follows: Formerly the intensity of the X-rays, which depends on the intensity of the cathode rays, could only be increased by increasing the potential difference applied to the tube and this also increased the penetrating power of the rays. In the Coolidge tube the intensity of the Cathode rays, and therefore of the X-rays, depends solely on the temperature of the tungsten spiral, and can be controlled by altering the resistance in the subsidiary heating circuit. The penetrating power of the rays is varied as before by changing the potential difference applied to the tube. In addition, as the cathode rays all proceed from the cathode, it is easier to focus them on the anode, and the focal spot does not move about as in the "residual gas" tube. The "softening" device is now unnecessary as is also the auxiliary anode. The anode itself is made of solid tungsten, because such a large amount of heat is developed by the impact of the cathode rays that a substance which is a good conductor of heat and which has also a high melting point is desired. If the discharge is too heavy or too prolonged even tungsten, the melting point of which is 3,000° C., may be fused.

After discussing the general practice of the X-ray application the author enumerates the various uses of the X-rays in industry. Probably the first industrial application of X-rays was their employment to locate pearls in oysters without opening them. The presence of pearl was indicated by the increased absorption of the rays. This examination has been abandoned, but the rays still serve the jeweler. By their aid he can distinguish real from artificial gems, the lead glass from which an artificial diamond is made, for example, being much more opaque to the rays than the real article. During the war extensive use was made of the rays for the examination of aircraft timber, spiral grain, hidden knots, resin pockets, grub holes and other defects in the raw material that can be recognized. Further, the soundness of assembled articles can be ascertained; a crack in the middle layer of three-ply wood can be detected. Another war application of the rays was the examination of innocent-looking and innocently-labeled consignments of goods for the presence of contraband of war. The X-ray examination of leather is a routine process in

some boot factories and sometimes the finished boots are also examined. Fiber for insulating purposes is frequently made from pulped rags and many contain metallic particles from a stray button. These particles can be detected and the labor involved in the manufacture of an insulator from faulty fiber can be saved. One of the most recent examples of the utilization of the rays in industry is the examination of chocolates for small pieces of metal or grit. In all these cases the examination can be carried out with a fluorescent screen, provided the objects to be examined are not too thick. Such articles can be carried on a belt between the tube and the fluorescent screen, and examined as they pass under the screen.

Examples of the materials which are examined photographically are quite as numerous. Light castings are examined for blow-holes. The soundness of welded joints can also be ascertained; in a bad weld the edges of the original plates can be seen on the photograph and blisters show up as light spots. The accuracy of assembly of metallic articles also calls for photographic examination. By this method, for example, it can be ascertained whether an insulated plate, such as is used in switchgear, is central with respect to the insulation. The material from which an article is made can also be ascertained. The mark on a steel casting may be machined off, but, as the various steels differ in transparency to the rays its identity may readily be reestablished. The thickness of the metal which can be examined in this way depends, of course, on its density. Gold being more than twice as dense as steel, the maximum thickness of gold which can be examined with any installation is less than half that of steel. The limiting thickness which can be examined at present is placed at various amounts by different workers. A pronouncement by Coolidge in this connection is interesting. He considers that it is practicable to make use of X-rays in the examination of steel having a thickness of not more than one inch. As the penetrating power of the rays available increases this maximum thickness will increase.

In addition to the uses of X-rays in the actual examination of materials, there is the moral effect upon the workman of the prospect of having his work so examined. If he knows that this examination will reveal that a weld may be bad, though the surface is good, he is less apt to neglect the interior of the weld.

AUTOMATIC HYDROELECTRIC PLANTS

While a small station which cannot afford high class engineers for its control and operation may have been fairly successful when it was an isolated station, now, when tied into the large distribution systems which cover the country, a much higher safety factor of operation is necessary since any serious trouble may involve the entire system. Therefore, aside from the economy resulting from the saving of the cost of attendance, reliability of operation makes it preferable to control and operate such small stations at a distance from a large station which can afford the quality of attendance giving the assurance of first-class operation. With the present-day development of electrical engineering it is possible to make the operation of the small station entirely automatic and thereby take its control out of the hands of the rather indifferent class of attendants economically available for such stations. Thus the automatic hydroelectric station is not merely an advance in economy which makes the operation of small stations possible, but it is an equal advance in the safety and reliability of the operation of these stations and therewith of the systems into which these stations connect.—Dr. C. P. Steinmetz in *The Electrical Review*, March 12, 1921.

Progress in Mining and Metallurgy

Abstracts of Papers and Recent Articles

Prepared Under the Auspices of the American Institute of Mining and Metallurgical Engineers

BREAKAGE AND HEAT TREATMENT OF ROCK-DRILL STEEL

By Benjamin F. Tillson

The development of rock drills to the hammer-drill type in place of the old reciprocating piston drill probably is one important cause for the greater steel breakage. Perhaps the manufacturers of drill steel have failed to realize what alloys are needed for this new service or have overlooked the changes in the art of rock drilling. The mine operator may be at fault in desiring to use the smallest possible drill-steel section in order that the gage of the drill bits may be correspondingly small and the amount of footage drilled per unit of labor may be greater; or the blacksmithshop practice at the mines may need improvement. The miner who uses the drill steel may also require more intensive supervision and education. Again, the manufacturer of rock drills may have failed to study the types of blows the steel alloys will withstand satisfactorily and which their tools are delivering and so he may not know whether or not a different design of rock drill would equal or excel their present drilling speeds without treating the drill steel so severely. All of these hypotheses probably have their supporters.

On the other hand, perhaps we are seeking too much service from drill steel and we need a fuller realization of the fatigue strains developed and should prepare to relieve these by a periodic heat treatment of the steels. However, we do not find any proof that any of these suppositions may be held responsible for the drill-steel breakage attendant to mining.

The proposed investigation of this matter by the U. S. Bureau of Mines is fully warranted in the promotion of the conservation of labor and material, and the safety of the workmen. The great range of field conditions, as well as the scope of the reasearch, requires the energetic coöperative support of many interests.

In order to direct our attention to what are thought to be some of the salient features of this research, the following preliminary outline has been prepared:

1. Study of steels that give the greatest service before failure by breakage of drill steel: (*a*) Nature of sections; (*b*) composition; (*c*) methods of manufacture.

2. Maximum service that might be expected: (*a*) Life of steel; (*b*) methods of heat treatment; (*c*) standard methods for recording service.

3. Mechanics of failure: (*a*) Micro-analysis; (*b*) nature of stresses; (*c*) detection of incipient failure: (1) Magnetic analysis; (2) other methods not destructive of bar of steel. (*d*) Is failure due to fatigue of metal?

4. Methods and machine development for accelerated tests: (*a*) Nature of forces involved: (1) Impact; (2) vibratory compressional waves; (3) combined bending, vibratory, shearing, and torsional.

5. Correlation of field tests with accelerated laboratory tests.

6. Reclamation of depreciated drill steels: (*a*) Before failure; (*b*) after failure; (*c*) methods of heating: (1) Oil-fired furnaces; (2) electric furnaces: resistance (carbon or nichrome); induction (high-frequency or low-frequency); (3)

ohmic resistance methods. (*d*) Welding of fractured steel: (1) electric; (2) forge.

LIFE OF DRILL STEELS

It is difficult to say what life or service should be expected from a bar of drill steel, as the conditions of field testing have many variables. However, within certain limits, we would probably agree to a minimum service. For instance, it would probably seem absurd that a 7/8-in. section of steel would not drill with sharp bits over 40 ft. of 1½-in. to 1¾-in. hole in pure limestone rock, before fracturing, yet some of the graphs accompanying this paper indicate poorer results. The maximum drilling recorded in these tests was about 281 ft.

MECHANICS OF FAILURE

It is not necessary to mention the various reasons why the microscope is invaluable in considering the metallurgy of steel nor the methods involved in determining the unusual conditions in composition, grain structure, and impurities that may occur in the drill steels. For the detection of the stresses that cause incipient failure, it is necessary to prepare a polished face along the length of the entire bar of drill steel, to protect this face from oxidation with a coating such as amylicetate, and to use every care when testing this steel to destruction. Such a procedure permits the detection of the local development of slip planes that occur at the surface of the steel, but it seems difficult to detect those originating within the bar.

The belief that the breakage of drill steel is largely due to the so-called "fatigue" of the metal has many proponents, but others contend that the problem of fatigue is of no importance and that the steel fails through lack of a homogeneous suitable structure and that faulty manufacture or subsequent abuse are responsible.

FORCES ACTING UPON DRILL STEEL

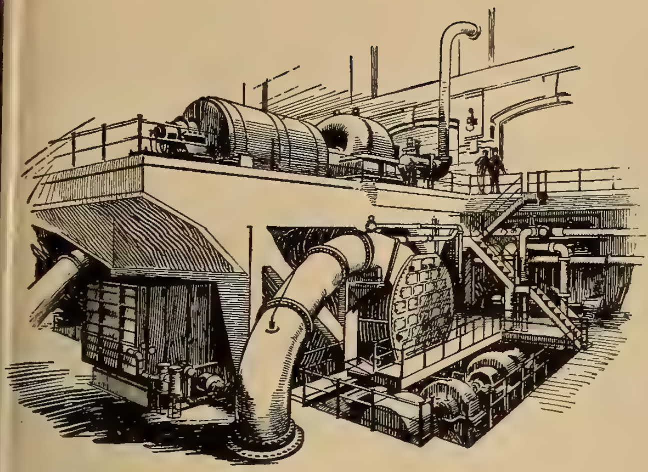
In order to get an idea of the magnitude of the forces acting on a drill steel, assume that a piston weighing 4 lb. makes 1,500 strokes per minute and travels 4 in. before it strikes the end of the drill steel; a drilling speed of 10 in. per min. advance of the drill steel in the rock, and a cross bit of 1¾ in. gage formed on the drill steel to cut the rock and rotated halfway around in an oscillating motion 50 times per minute, the cutting edges of the drill bit are formed by planes meeting at 90° and presenting a surface 0.005 in. wide when sharp. Then the penetration of the drill steel in the rock will be about 0.1 in. per blow. The kinetic energy of the piston is about 69 ft.-lb. and the total average pressure on the rock will be about 8,300 lb. if the compressibility of the piston, the drill steel, and the rock are ignored as relatively small factors when compared with the depth of penetration in the rock. The crushing strength of granite is estimated from 12,000 to 20,000 lb. per sq. in.; we will use 14,300 lb. per sq. in. If the initial pressure of contact of the steel against the rock equals this value, the final pressure would be 16,350 lb. or 22,800 lb. per sq. in. of drill bit in contact with the rock at the end of the penetration. This is about 60 per cent more than the pressure required to crush the rock, so a corresponding portion of the force of the blows does no useful work but would be returned as a reaction through the drill steel if both bodies were perfectly elastic. The coefficient of restoration of steel, however, is ordinarily given as about 56 per cent, so that the rock could not return quite all of this excess force as a reaction on the steel. If it is assumed that this steel has a modulus of elasticity equal to 29,000,000 lb. per sq. in. and a density of 489.6 lb. per cu. ft., the velocity of propagation of sound waves through it will be 16,550 ft. per sec., and as the time in which the piston is delivering its energy to the steel is 0.0005 sec., the wave lengths will be about 8,275 feet.

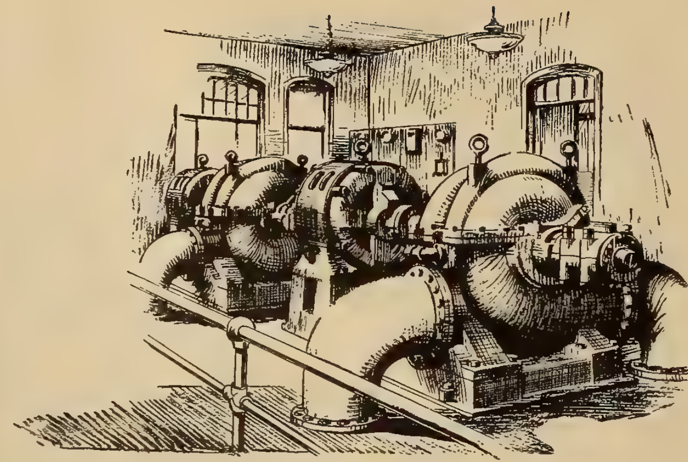
Among the principles that govern the transmission of compressional waves are the following:

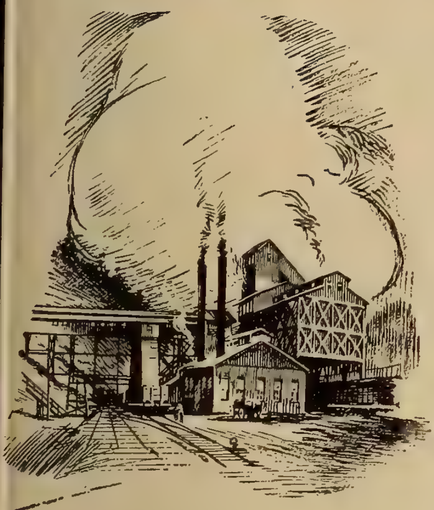
1. When a longitudinal or compressional wave passes from one medium to another, a part of the energy is reflected and a part transmitted. The phase of that part reflected is changed one-half of a wave length when the reflection occurs in the denser medium. When the reflection occurs in the lighter medium the phase of the wave is unaltered.
2. Two waves of the same length, but differing in phase, combine to produce a wave of the same length but different amplitude and phase than either of the initial waves.
3. Two waves of the same period and amplitude, but differing in phase by a wave length, combine to produce a wave of the same length but double amplitude.
4. Two waves of the same period and amplitude but differing in phase by a half wave length mutually annul each other.
5. Two waves that differ slightly in length combine to produce a wave of varying amplitude. Its frequency is one-half the sum of its component frequencies. If both initial waves were of the same amplitude the amplitude of the resultant wave will vary from zero to twice the original amplitude as many times per second as the difference of their frequencies.
6. When two equal waves transverse in opposite directions, the resulting wave remains stationary. The node in the resultant wave occurs half way between the similar zero points of the original waves; and the points of greatest amplitude occur one-quarter of a wave length away. Therefore nodes occur at distances that are multiples of half wave lengths.—Abstract of paper presented at the New York Meeting, Feb., 1921, of the Amer. Inst. of Min. and Met. Engineers.

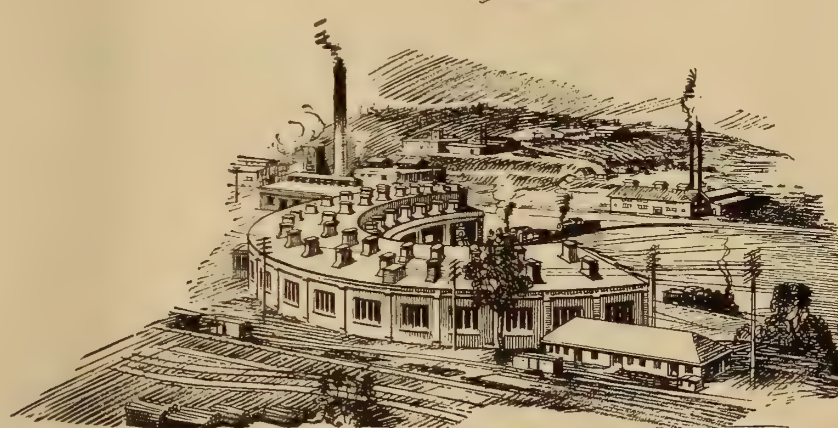
CIRCULAR 20-FT. VERTICAL SHAFT 7,000 FT. DEEP

An account of the scheme that has been adopted for working the City Deep mine at a depth of 7,000 ft. was given before the Institution of Mining and Metallurgy by Mr. E. H. Clifford. The mine is now being operated from two vertical rectangular seven-compartment shafts 4,000 ft. apart, 3,300 and 4,000 ft. deep, respectively. From the bottom of these shafts extend two five-compartment inclines which lie under the reef and are connected with it by cross-cuts at each level. The west shaft has reached the 20th level, and the east the 18th level. The vertical depth of the 20th level is 4,950 ft. The inclines will soon have reached the vertical depth at which troubles with rock pressure are likely to become serious, and their length will have reached the economic limit. There will thus remain an area equal to about one-third of the property which is not provided for by present appliances, and the scheme adopted in solution of the problem of exploiting it consists in sinking a vertical shaft of circular section 7,000 ft. deep in two stages of 4,500 ft. and 2,500 ft. The upper section will stop at the 17th level, where it will make connection with the two incline shafts, and the reef will be attacked from the lower section of the shaft by cross-cuts at each level. The shaft is 20 ft. in diameter in the clear, and is fitted with concrete rings spaced at 10 ft. vertical intervals. The rings are each 18 in. deep by 15 in. wide, and their function is to provide adequate fastenings for the shaft-guides, pipes, cables, etc., and also to afford a foundation for any form of lining that may be found necessary. The capacity required of the shaft is 2,000 tons of ore per 24 hr., plus all the men, natives, and materials necessary for this output. The cage is to be 15½ by 5¼ ft., with two decks, and will be made of alloy steel, as the saving in weight thereby effected will materially increase the working life of the winding ropes, diminish the consumption of power, and more than compensate for the additional cost. An existing double inlet Sirocco fan, 154 in. in diameter, with a capacity of 420,000 cu. ft. per min. at 2½ in. water gage, is now being run at only about half its capacity, and the surplus cooling power will be sufficient to offset the growing extension of the mine for a long time to come. Of the 300,000 cu. ft. that will be made to travel through the new shaft, 75,000 cu. ft. will be required to cool the electric winder and converter sets at the 17th level station, the remainder being directed through the lower shaft to the bottom workings.—Summary of paper presented before the Institution of Mining and Metallurgy.









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"MOUNTAIN CRAFT"—A STIFF CLIMB UP THE EISMEER, THE FAMOUS SEA OF ICE, IN THE JUNGFRAU DISTRICT OF THE BERNESE OBERLAND, SWITZERLAND (SEE PAGE 551)

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THE CHEMIST MILITANT

THE important part that chemistry played in the great World War is now an old story. Today we are being warned that new terrors are being prepared for the next great struggle which will make the recent one pale by comparison. But not very much is being written about the chemical war that is now being waged in which millions of the enemy are being poisoned by chemicals—the war against the hordes of parasites that invade the human organism.

Remarkable progress has been made in the use of serums for combating certain diseases, but there are some protozoic infections which do not yield to the serum treatment, and in such cases the chemist is called in to wage war with poisons. His problem is to find a substance which will kill the pathogenic parasites without doing injury to the human organism.

The problem is complicated however by the fact that living matter is to be dealt with. Reactions that seem perfectly satisfactory as performed in the test tube fail to show the same reaction in the human body. Experiments on animals vary with different animals and hence offer no definite clue as to how the human organism will behave under the same conditions. There is even a difference of behavior in different parts of the same animal. So many variables enter into the problem that the chemist's problem of selective poisoning is an exceedingly complex one. How may he be sure that the foe will partake of the poison and the friend will abstain?

Ehrlich in his researches that led eventually to the discovery of "salvarsan," worked upon a theory borrowed from that upon which the synthetic production of dyestuffs is based. He recognized a chemical affinity between certain chemical groups in the living cells and certain chemical groups in the substances they absorbed. He pictured the living cell as consisting of a central nucleus surrounded by a group of atomic bonds which he termed "receptors." According to the theory these "receptors" are the active guardians of the nucleus and exercise selective judgment as to what may be admitted to the nucleus. They are very mobile and ready to detach themselves from or reunite themselves with the nucleus, according to circumstances. To be sure the receptors possess no reasoning powers in discriminating against certain substances but merely accept that substance which possesses atomic groups for which they have a chemical affinity and they are indifferent to all others.

A simple outline of the theory may be found in the article entitled "Chemical War on Disease," beginning on page 503. While there has been much criticism of the theory, it appears to account for most of the complicated phenomena involved and furnishes us with a working hypothesis. It enables us to visualize probable conditions that are beyond the reach of the microscope and it gives us a most fascinating picture of the war which the modern chemist wages within the very body of man.

SEAPLANE FOREST PATROL

IMMEDIATELY after the World War, when efforts were made to find peace-time uses for the airplane, it was suggested that the flying machine would prove of value in patroling our great forest reserves to detect the first evidences of fire and thus guard against widespread destruction of valuable timber lands. The airplane was tried out over our western forest and proved a very valuable ally to the fire patrol.

A similar flying patrol was instituted by a company owning large timber lands in Quebec, but in this case instead of airplanes, *flying boats* were employed. This seems like a strange vehicle for use over land until we learn that of the area which covers 160 by 270 miles, about seven per cent is water. Numerous lakes are widely distributed throughout the tract, and they furnish excellent landing places for the seaplane, should they have to come to earth owing to any mishap. Flying at an altitude of five thousand feet they are always within gliding reach of one of these bodies of water. The forest reserve is of such an extent that it takes between two and three years for logs from certain remote regions to reach the mill. This is due to the fact that a portion of the reserve is on a slope that drains into Hudson Bay. The winged patrols have a bird'seye view of from forty to eighty miles and can rush fire fighters to any point in a minimum of time.

An interesting description of this air service may be found in the May issue of *American Forestry*.

The seaplane patrol is maintained not only for the purpose of detecting fires, but also to explore the tract and determine the character of the timber. Photographs are taken from the seaplane and it is possible to tell from the nature of the surface whether the timber is of soft wood or hard wood. The crowns of soft wood are round and give the effect of depth, while the tops of hard wood are irregular and flatter. The camera merely shows the distribution of hard and soft woods but does not give any clue as to the species of the woods. This, however, may be determined visually. The practice is to take a series of photographs and then go over the ground again with an experienced woodsman who can tell from the color and general appearance what species of timber are. He also fills in any parts that are not clearly revealed in the photograph. In this way it is possible to map the tract and its resources very accurately.

Seaplanes have also proved valuable in familiarizing logging bosses with the regions in which they are to operate and they have also been used to take company officials over various territories. A recent expedition of 850 miles was made in 12½ hours. This included a number of stops for closer inspection and one stop for the taking on of fresh fuel. Incidentally the seaplanes are equipped with Liberty motors which were left in Halifax by American forces and these engines have proved remarkably reliable.

Planetary Motions and the Einstein Theories

A Possible Alternative to the Relativity Doctrines That Would Save the Newtonian Law

By Charles Lane Poor

Professor of Celestial Mechanics, Columbia University

THE entire Einstein theory of the universe is based upon two or three pure assumptions as to the fundamental constitution of nature. These are so broad and general in character that they cannot be directly tested. But, if they are provisionally accepted as true, it is possible to build upon them a complete and logical theory of the universe and of the laws governing the motions of all the bodies therein. This Einstein has done with great technical skill, with results that are remarkable and, to say the least, very startling to our preconceived ideas of space and time. It is through these results, through the logical deductions and formulas derived from his postulates, that the hypotheses themselves can be tested.

In order, however, to establish the Einstein theories it will not be sufficient to show that the facts of nature can be explained by the Einstein formulas; it must be conclusively shown that no other hypothesis will equally well explain the observed phenomena. In the words of the mathematician, it is essential for the followers of Einstein to show that his hypotheses and formulas are *necessary and sufficient*.

For many years the Newtonian law as applied by mathematicians has failed to account accurately for the motions of Mercury, and this failure has been made the basis of many attacks upon the Newtonian law, of which Einstein's is merely the latest and best executed. The orbit, or path, of any planet, such as Mercury, about the sun is an immense oval, or ellipse, one diameter of which is longer than the others. This diameter is known as the axis of the orbit. Now, if Mercury were the sole planet in the system, then, under the Newtonian law, this axis would remain fixed in direction; but, under the Einstein law, it would rotate slowly at the rate of 43″ of arc per century. Under such conditions a clear cut issue would be presented, and observations could at once decide between the two theories. Mercury, however, is not the only planet, and the action of the earth and the other planets upon him causes a similar and a much larger rotation of the axis, the exact amount of which can be found only after long and complicated computations. These calculations give 537″ per century and, if the Newtonian law be exact and the *computations correct in every particular*, the axis of Mercury's orbit should rotate by this amount. Direct measurements upon the positions of the planet in the heavens, however, show this rotation to be 579″, or an excess of 42″ over the amount yet accounted for by the Newtonian law, and in extremely close accord with the rate of motion predicted by the Einstein formulas.

At first sight this striking agreement of figures appears to confirm the Einstein theories in a brilliant manner. But, striking as these figures are, the confirmation is not complete, for it is possible to explain the motion of Mercury in full accord with the Newtonian law and in accordance with accepted scientific facts.

The whole matter depends upon the calculations through which the figure 537″ was found. Now it is well known to every mathematical astronomer that these calculations are not complete, that they do not take fully and completely into account all of the bodies of the solar system. In the theories and formulas upon which these calculations depend the sun has been considered as a perfect sphere and all space between the sun and the various planets as free from all gravitational matter. These are necessary mathematical simplifications: Without them the equations of motion would be impossible of solution. These simplifications approximate very closely to the truth and the results obtained by their use very closely represent the motions of the planets, but they are *approximations* and it necessarily follows that the results do not represent the actual motions with complete accuracy.

Every photograph taken, every measurement made of the sun and the various planets show that these assumptions, upon which the simplifications are based, are not true. Neither the sun nor any one of the planets is a perfect sphere. The polar axis of the earth is considerably shorter than the equatorial; a glance through any telescope shows Jupiter to be decidedly elliptical. The sun-spots, which can be seen with an ordinary small telescope, show that the sun is not of uniform shape and density. Exact measurements of the shape of the sun are extremely difficult to make, yet every series of measures, heretofore made, show distinct departure from a true spherical form.

Passing outward from the sun itself one finds the corona. At times of eclipse this halo, or brilliant crown about the sun, can be seen by the unaided eye. It has been sketched many times, it has been photographed times without number. Its presence proves the sun to be surrounded by an envelop of matter of irregular shape and of vast size. This envelop is in general lens-shaped and it extends far out beyond the orbit of the earth.

The exact size, shape and constitution of this envelop is not known; its density is extremely small and the total amount of matter contained in it cannot be very large. It is known, however, that it is not a true gaseous atmosphere of the sun like that of the earth. It consists, in the main, of widely scattered, minute solid particles, each traveling about the sun in its own independent orbit. Some of these bodies may be as small as pin-heads, others many feet in diameter. The zodiacal light is recognized as mainly sun-light reflected from such minute bodies, each too small to be seen separately, but, as a group or mass, reflecting enough light to show as a faint glow against the dark sky.

While matter is thus known to exist in the vicinity of the sun and the inner planets, its effect upon the motions of these planets cannot be absolutely calculated until its distribution is fully known. It is clear that the figure 537″ per century does not accurately represent the motion of Mercury's perihelion under the Newtonian law; but, in the present state of our knowledge of the solar envelop, it is impossible to correct definitely this figure and to state what the final value should be.

Further, the discordance in the motion of Mercury is only one out of eight or ten similar discrepancies in the motions of the planets. Einstein and his followers have stressed the supposed explanation, under his theories, of the motion of Mercury, but have glossed over the necessity of finding an explanation for the remaining discrepancies. Now the theories and formulas of Einstein account partially for one or two of these other difficulties, completely fail to account in the slightest way for others, and finally greatly increase the discordance in the case of Venus. In fact, in the case of this planet, the Einstein formulas would give the orbit a rotation in the opposite direction to that which is required to fit the observations.

According to Newcomb the secular motions of the elements of the four inner planets, as observed and as computed, are as given in Table I. The column of differences contains the unexplained portions of the motions of the planets. That is, in one century the perihelion of Mercury moves 41.6″ of arc more than can be accounted for, while that of Venus does not move quite so swiftly as the computations would lead one to expect. These unexplained portions of the motions are the so-called "discordances" or "discrepancies." That of the peri-

helion of Mercury is especially well known and has figured prominently in many attempts to prove false the law of Newton. The perihelion of Mars shows a large discrepancy, as do also the nodes of both Mercury and Venus.

In the column of differences, after each discordance, is given the "probable error" as determined by Newcomb. While these may give some idea as to the relative accuracy of the various determinations, it must be remembered that the assignment of these probable errors is very largely a matter of judgment, and that the values may have been over or under estimated. In every step of the long and complicated computations and reductions, an estimate, rather than an exact calculation, has to be made as to the value of the probable error, and the final value, as given in the table, thus depends upon many separate estimations or judgments. But, taking these probable errors as given by Newcomb, it will be noted that out of the ten differences six are larger than the corresponding probable errors, and of these six, three stand out prominently: The perihelion of Mercury, the perihelion of Mars, and the node of Venus.

TABLE I.

PERIHELIA:	Obsd.	Compt.	Diff.	Plus or Minus	P.C.
Mercury.....	+ 579.2″	+ 537.6″	+41.6″	1.4″	+ 7.2
Venus......	+ 42.4	+ 49.7	− 7.3	22.3	−17.2
Earth.......	+1161.5	+1155.6	+ 5.9	5.6	+ 0.5
Mars........	+1605.9	+1597.8	+ 8.1	2.6	+ 0.5
INCLINATIONS:					
Mercury.....	+ 7.14″	+ 6.76″	+0.38″	0.54″	+ 5.3
Venus.......	+ 3.87	+ 3.49	+0.38	0.32	+ 9.8
Mars........	− 2.26	− 2.25	−0.01	0.14	− 0.4
NODES:					
Mercury.....	− 753.0″	− 758.1″	+ 5.1″	2.8″	+ 6.8
Venus.......	−1780.7	−1790.9	+10.2	2.0	+ 0.6
Mars........	−2248.9	−2249.8	+ 0.9	4.6	+ 0.0

The final column in the table gives the percentage that the discordance bears to the observed motion. While this is rather an unusual way of comparing results, it may be of interest and may throw some light on the problem. It will be noted that five of the differences represent very large percentages of the observed quantities, and of these five, three are among the six that exceed their probable errors. These three are in the motions of the perihelion of Mercury, the inclination of Venus, and the node of Mercury.

The discordance in the perihelion of Venus is peculiar. It amounts to over 17 per cent of the entire observed motion, and yet it is only one-third of the apparent probable error. It would seem that where the percentage is so large, the discordance must be real, and that the value of the probable error has been overestimated.

According to the Einstein theory, as noted above, the perihelia of the planets would rotate by various amounts depending upon their respective distances from the sun. This Einstein rotation is independent of the mutual action of the planets upon one another, and in order to find the total motions under the Einstein theories, it should be added to the computed motions as given in the above table. This is shown in Table II, which also gives the final outstanding differences between theory and observation, as based upon the Einstein theory.

TABLE II (Perihelia)

	Newtonian Computation	Einstein	Total	Diff.	P.C.
Mercury...	537.6″	42.9″	580.5″	− 1.3″	0.2
Venus.....	49.7	8.6	58.3	−15.9	37.5
Earth.....	1155.6	3.8	1159.4	2.1	0.2
Mars......	1597.8	1.3	1599.1	6.8	0.4

Thus the Einstein motion is sufficient to account for practically all the discrepancy in the case of Mercury and to reduce in a marked manner that in the case of the Earth. It accounts, however, for a very small part of the discordance in the case of Mars, and more than doubles the already large discrepancy in the motion of Venus. Further the Einstein law does not in any way account for the important discrepancies in the motions of the nodes and in the inclinations of the planets.

Turning now to the matter which is known to exist in the vicinity of the sun and planets, while as we have said we cannot determine its quantity and general distribution, it is perfectly possible and reasonably easy to find what distribution of this matter would under the Newtonian law, give a motion of 42″ to Mercury's perihelion, and thus make the total motion 579″, as required by observation. This problem is similar to that solved by Adams and Leverrier, which resulted in the discovery of the planet Neptune. Moreover, it is then found that the distribution that will explain the motion of Mercury will fully explain that of the other planets; it will give the orbit of Venus the necessary rotation, both in direction and in amount. What the Einstein formulas fail to explain, the presence of a great lens of matter about the sun explains fully and satisfactorily.

The quantity of matter required in the solar lens for this purpose, and the distribution which it becomes necessary to assign to it, are entirely within the limits of reason. The matter in the immediate vicinity of the sun would tend to group itself about a plane somewhere near that of the solar equator, or that of the orbit of Mercury; while matter at a considerable distance from the sun would tend more toward the invariable plane of the solar system, which is nearly the same as that of the orbit of Jupiter. Further the density of the matter will decrease as the distance from the sun increases. This general distribution can be approximated by assuming the whole mass to be made up of ellipsoids of revolution, each ellipsoid of uniform density, but the larger ones of much less density than the inner ones. Some such assumption is necessary to reduce the problem to the realm of figures; the selection of ellipsoids of revolution is naturally indicated by the fact that all the known bodies of the solar system are such ellipsoids.

For purposes of computation the mass may be supposed to be made up of superimposed ellipsoids, each of constant density. This merely makes the changes in density abrupt, instead of gradual. Three such ellipsoids are necessary and sufficient to account for the motions of the perihelia of the four planets:

a. A small central ellipsoid entirely within the orbit of Mercury, and embracing only the matter in the immediate vicinity of the sun. The position of this ellipsoid in space was determined from equations of condition derived from the discordances.

b. An intermediate ellipsoid entirely within the orbit of the earth, but extending beyond the orbit of Venus. The principal plane of this ellipsoid was assumed as being the same as that of the orbit of Jupiter.

c. An outer ellipsoid entirely within the orbit of Mars, but extending beyond the orbit of the earth. The principal plane of this ellipsoid was assumed as being the same as that of the orbit of Jupiter.

The mass, or density, of each ellipsoid is a function of its radius and cannot be independently determined. The radii can, however, be assumed arbitrarily and the corresponding masses and densities found. With an assumed ellipticity of 0.9 and assumed radii we have:

	Assumed radii	Corresponding densities
Inner ellipsoid	0.05	1.2×10^{-7}
Medium ellipsoid	0.98	1.7×10^{-13}
Outer ellipsoid	1.36	7.4×10^{-14}

where the density of the sun is unity. If the inner ellipsoid be assumed to be of larger radius, then its density would be correspondingly less.

With the assumptions thus outlined, the motions of the planets were calculated. The results appear in Table III on the following page:

The relative probabilities of two solutions of a problem are usually determined from the final differences or residuals, as these differences are called. That solution is deemed the most

probable which makes the sum of the squares of the residuals the smaller. If this test be applied to the residuals obtained in Table II with the Einstein theory as the basis and to those from Table III, the results are:

Einstein theory....................	438.38
Solar envelop.....................	14.07

And these clearly indicate how very much more probable is the explanation of the motions of the planets as due to the presence of matter in space, than by the hypotheses of Einstein.

TABLE III

	Motion due to Solar Envelop	Total Motion	Final Diff.
PERIHELIA:			
Mercury..............	+41.6″	+ 579.2″	0.0″
Venus................	— 7.5	+ 42.2	+0.2
Earth................	+ 5.9	+1161.5	0.0
Mars.................	+ 6.9	+1604.7	+1.2
INCLINATIONS:			
Mercury..............	+0.37″	+ 7.13″	+0.01″
Venus................	+0.45	+ 3.94	—0.07
Mars.................	+0.12	— 2.13	+0.12
NODES:			
Mercury..............	+ 4.9″	— 753.2″	—0.2″
Venus................	+ 9.1	—1781.8	—1.1
Mars.................	+ 4.3	—2245.5	—3.4

Einstein and his followers have cited the motions of the planets as conclusive proof of the truth of his hypotheses. The evidence does not sustain this—his hypotheses and formulas are neither *sufficient* nor *necessary* to explain the discordances in these motions. They are not *sufficient*, for they account for only one among the numerous discordances—that of the perihelion of Mercury; they are not *necessary*, for all the discordances, including that of Mercury, can readily be accounted for by the action, under the Newtonian law, of matter known to be in the immediate vicinity of the sun and the planets.

Thus the motions of the planets do not prove the *truth* of the Einstein theory, nor, on the other hand, do they prove its *falsity*. While these motions can be accounted for by a certain distribution of matter in the solar envelop, it has not yet been established by observation that the matter is distributed through space in the required way. In the present state of our knowledge regarding this matter, the motions of the planets do not and cannot furnish a definite answer to the question as to the validity of either hypothesis. It is then a problem of observational astronomy to investigate the actual distribution and density of the matter in the solar lens, and to determine whether or not it approximates the conditions necessary to account for the planetary motions. In 1908-10, before Einstein had developed his astronomical theories, I called attention to the desirability of doing this; but the astronomical world could not see the need of the investigation and it was never made.

NEW OBSERVATIONS ON THE VARIABILITY OF THE SUN

(*a*) SIMULTANEOUS spectro-bolometric observations of the solar constant of radiation in California and Algeria in 1911 and 1912, and in California and Chile in 1918, (*b*) comparisons of the distribution of radiation over the sun's disk with simultaneous measurements of the intensity of total solar radiation, (*c*) comparisons of the temperature of the earth with the radiation of the sun, and (*d*) several other minor evidences, have all indicated a short irregular periodicity in the sun's omission. In other words, the sun appears to be a variable star ranging through about 0.10 stellar magnitude between extremes and often changing 0.03 magnitude within a few days.

For about six years the intensity of solar radiation has almost always exceeded the mean value, 1.933 calories per square centimeter per minute, which was found from the Washington, Mt. Vernon and Mt. Whitney observations of 1902-1912, as published in Vol. 111 of the Annals of the Astrophysical Observatory. This condition of affairs was expected to attend the return of increased solar activity, otherwise evidenced by numerous sunspots, prominences, faculæ. We have now, however, long passed the period of maximum sunspots, so that we should naturally expect the sun's radiation to be falling below the mean value of 1902-1912. The results obtained by the Smithsonian observers at Calama, Chile, indicate quite otherwise.

I have computed solar radiation values for each five days' interval from July 1, 1919, to March 25, 1920. The mean value is never based on less than two observations, and this minimum occurs only in two instances. All other values depend on three days of observation, more often four, and very often five.

One is immediately struck by the wide fluctuation of the mean values shown. The fluctuation of individual days naturally had a still wider range, reaching in fact to 8 per cent. The mean values cover a range of 5 per cent. With gradually diminishing swings, up and down, the radiation fell from June, 1919, to early in October, then suddenly leaped up to a high mean value which it maintained until early in December, and then again suddenly leaped much further and remained from the end of December to the middle of March, 1920, at a mean value far in excess of anythings which we have any record of, continued for so long a time as three months during the whole fifteen years in which solar constant observations have been carried on with anything like regularity. Toward the end of March an extremely rapid fall of radiation occurred so that individual values have run as low as 1.86 calories.

In view of this extraordinary march of solar radiation values, it may be recalled that we passed through an exceptionally cold and cloudy winter from about the first of December, 1919. The cloudiness prevailed in South America as well as here, so that if it had not been for the introduction of the new method of observing, of which notice was given to the Academy at its last meeting, the observers would not have been able to give us this very continuous record.

At first sight it looks paradoxical that a cold winter could accompany extraordinarily high values of solar radiation, but it has been not only a cold winter, but a cloudy winter. Hence it may have been that the direct effect of the outburst of solar activity was to produce excessive cloudiness which by high reflection diminished the radiation available to warm the earth.—Abstract of article by C. G. Abbot, Astrophysical Laboratory, Smithsonian Institution, Washington, in Proceedings of the National Academy of Science for November, 1920.

BENGAL'S DISASTROUS CYCLONE

THE Meteorological Department of the Government of India has issued its report on the administration in 1919-1920. Observations in connection with the upper air have been developed on behalf of the aviators who are from time to time crossing India. Storm warnings for stations in the Bay of Bengal and in the Arabian Sea are said to have been carried out successfully. It is, however, admitted that the warning of the great storm on the night of September 24, 1919, was inadequate. The storm crossed the Bengal coast as a cyclone about noon on September 24. It reached Dacca at about 2:30 A. M. on September 25, and finally broke up on that day in the Assam hills. At the center the deficiency of pressure was about 1¼ inches, and the calm area at least 15 miles in diameter. The total loss of life is estimated at 3,500. The value of property destroyed was probably greater than in any storm in Bengal for the last two hundred years, but the destruction of human life was probably greater in the Bakarganj cyclone of 1876. An additional terror was caused by a vivid red glow appearing in the sky during the period of the lull.—From *Nature* (London), April 28, 1921.

THE EGYPTIAN EXPEDITION OF THE METROPOLITAN MUSEUM OF ART, 1918-1920, BRINGING ITS FINDS TO A PLACE OF SAFETY

Egyptian Life Four Thousand Years Ago

How the Most Famous Noah's Ark in the World Came to the Metropolitan Museum of Art

(Photographs by courtesy of the American Museum of Art.)

IN the SCIENTIFIC AMERICAN for May 7th, there was published a brief article entitled "Looking Backward 4,000 Years," and now through the courtesy of the Metropolitan Museum of Art, we are enabled to publish a number of additional pictures and in lieu of the conventional article on the subject, we have decided to use the exact words of two members of the Expedition, Messrs. Lansing and Winlock, the latter being in direct charge of the Expedition. Their narratives bristle with interest and suggest "Captain Kidd" or "Treasure Island," but the best of it all is that it is *real* and one-half of the "find" is in the sixth room of the Egyptian Department in the great musuem on Fifth Avenue.

"In the course of the work of the Egyptian Expedition of the Metropolitan Museum of Art on its concession on the west bank at Thebes, our attention had been drawn," says Mr. Ambrose Lansing, "to that part of the site south of Deir el Bahri, among the spurs and cliffs of the mountain which separates the Valley of the Kings from the plain. Here, during the troublous times in Egypt, a good deal of plundering had been going on, and in forestalling some of this unauthorized digging I had been fortunate enough to find the burial-place of a young prince of the Eighteenth Dynasty, who had been torn to pieces by ancient tomb robbers in their search for gold, and had then been reburied by the priests of the Twenty-first Dynasty. The tomb had been in an almost inaccessible cranny of the cliff wall, and similar clefts in the rock face looked as if they too might contain hidden tombs.

"At the beginning of the season of 1919-1920, these were thoroughly cleared, but not a trace of occupation was found. A huge tomb of the Eleventh Dynasty—from its size and position evidently that of a high offcial [The noble—he was a prince and chancellor of the kingdom about 2,000 B.C., by name Mehenkwetre (an Egyptian equivalent of Heliodorus).] of the last of the Mentuhoteps—looked as if it might give us a chance of recouping our fortunes. Mr. H. E. Winlock, who was in charge of the excavation, looked it up and found that work had been done on it in 1895 by Daressy, and that he had found fragments of finely painted relief there. We could see that the clearing of the forecourt at least had not been thoroughly done, and it was there that the sculpture had been found. Mr. Winlock finally decided that it was as good a chance as any, and the men were set to work there.

"A very few days' work with a big gang of workmen laid bare the platform which had been the forecourt of the tomb. It had originally been in the form of a portico, and the walls had been built of fine imported limestone sculptured in low relief, and painted with a delicacy rarely equaled in Egyptian art. But of this only a few fragments were found, none of them as much as six inches square, and they only resulted in making our disappointment the keener. Two mauls, so rough that, if found in other circumstances, they would have been taken for Palæolithic implements, suggested the ruthless manner in which the ancient quarrymen had broken up the sculptured blocks for building-stone.

"So our hopes were dashed again. In order to get an adequate plan of the tomb, it was necessary to clear the corridors and the two burial shafts. We were sure that we should get nothing in the way of antiquities in doing this, for the previous excavator had evidently dug them thoroughly, and the débris appeared to be nothing but stone fallen from the walls and ceiling. Still a good plan is better than nothing, and is always of interest to the archæologist, if not to the layman. So, as it is our practice always to clear and plan thoroughly, we felt obliged to do so in this case. Conscientiousness was rewarded.

"In clearing the fallen rock from the main corridor, a workman dislodged a loose stone from the side near the floor, and the small chips began trickling into a small dark hole. It was the evening of March 17. Mr. Burton was in charge of the work, and was called by the excited foreman. The hole was small, and the passage dark, and even matches helped little to show what was hidden within. A hurriedly written note brought Mr. Winlock and myself up from the house with an electric torch. Each of us in turn glued his eye and the torch to the hole in the rock. None of us expect ever again to have such a sight appear to us. 'The beam of light shot into a little world of four thousand years ago, and I was gazing down into the midst of a myriad of brightly painted little men

WHAT WAS SEEN THROUGH A CRACK IN THE ROCK

The world of 4,000 years ago in brightly painted miniature as revealed by the electric torch. The girl still poised her basket of meats and stared stonily at the invader

going this way and that. A tall, slender girl gazed across at me perfectly composed; a gang of little men with sticks in their upraised hands drove spotted oxen; rowers tugged at their oars on a fleet of boats, while one ship seemed foundering right in front of me, with its bow balanced precariously in the air. And all of this busy going and coming was in uncanny silence.'

"It was too late to do anything except to seal up the crack, set a guard for the night, and speculate till late on what we thought we had seen, and what the morning would bring to light. The next three days were the busiest of our several careers. To clear that small chamber of its contents before the change of air loosened the friable shale of the ceiling, and yet not to remove the different objects before all the evidence was recorded and the necessary photographs taken, was a job requiring hard work and nice judgment. But it was done; and just in time, for, soon after we had everything out, the stones began to fall."

Mr. Winlock continues this interesting narrative as follows:

"As we worked along through those three days and nights we began to realize what it was that we had so unexpectedly discovered. The tomb was that of a great noble of four thousand years ago. He himself had been buried in a gilded coffin and a sarcophagus of stone in a mortuary chamber deep down under the back of the corridor, where the thieves had destroyed everything ages before our day. Only this little chamber had escaped, and it was turning out to be a sort of secret closet where the provision was stored for the future life of the great man.

"He could not conceive of an existence in which he would not require food and drink, clothing and housing, such as he was used to in this life; and, being a rich man, naturally he wanted an estate in eternity like that which he had owned on earth. His philosophy carried him beyond that of the savage chieftain who expects a horde of servants to be slaughtered at his grave. He attained the same end by putting in his tomb a host of little wooden servants, carved and painted, at their daily tasks, working before little portraits of himself. The spirits of these little servants worked eternally, turning out spirit food or sailing ships upon a spirit Nile, and his soul could enter any one of the little portraits of himself at will to reap the harvest of their labors. In short, we had found a picture of the life the great noble hoped to live in eternity, which was nothing more or less than the one he had led on earth forty centuries ago.

"The first thing we had seen when we had peeped through the cack had been a big model nearly six feet long, showing the noble seated on a porch among his scribes, taking the count of his cattle as they were driven past. In the back of the room we found, under a lot of other models, neatly stacked, the stable where these same cattle were being fattened, and finally when we came to move one big box-like affair in the far corner—a model I had tried my best to get a peep into and almost fallen headlong in the process—we found it was the butcher-shop where the cattle's life history ended. The night we worked in the tomb by lamp-light we got a peep into a granary where diminutive scribes sat writing down the quantity of grain being measured and carried to the bins by hard-working laborers. And later we ran across the bakery where the grain was ground and made into loaves, and the brewery where the home beverage was being fermented in tall crocks and then decanted into round-bellied jugs. Mr. Lansing extricated two canoes manned by fishermen, who hauled a miraculous draft of painted wooden catfish and perch in a seine; and I picked the fallen stones out of two gardens in which copper ponds--that would hold real water—were surrounded by little

wooden fig-trees and cool, shady porches. Then there was a carpenter-shop, and another shop where women spun thread and wove cloth. The very threads on their distaffs and spindles—frail as cobwebs though they were with age, had remained unbroken in that eternal stillness.

"Thus had the great man lived, and so did he expect to live after he had gone to his 'eternal abode,' as he called it. Finally, the funeral day had come. His body was brought across the river from his mortal home in Thebes, through the green fields where the wondering peasants leaned on their hoes to watch it pass, and then up through the rocky gorges to his tomb. A long procession followed him, each model borne on the head of one of his serfs, and a crowd of peasant girls and women from his estates brought baskets of wine and beer and baked meats for the funeral banquet. Even their contributions were expected to go on for ever, and statues of two of them, half life-sized, had been made to go with the models in the chamber. There we found them, towering above the horde of miniature men and beasts, looking over at us with grave, wide-open eyes. Four thousand years they had stood thus silent.


STEWARD GUARDING TRUNKS UNDER A BERTH IN A MINIATURE BOAT

"Four thousand years is an eternity. Just saying it over and over again gives no conception of the ages that have gone by since that funeral. Stop and think of how far off William the Conqueror seems. That takes you only a quarter of the way back. Julius Cæsar takes you half-way back. With Saul and David you are three-fourths of the way, but there remain another thousand years to bridge with your imagination. Yet in that dry, still, dark little chamber those boats and statues had stood indifferent to all that went on in the outer world, as ancient in the days of Cæsar as Cæsar is to us, but so little changed that even the finger-prints of the men who put them there were still fresh upon them. Not only finger-prints, but even fly-specks, cobwebs, and dead spiders remained from the time when these models were stored in some empty room in the noble's house waiting for his day of death and burial. I even suspect that some of his grandchildren had sneaked in and played with them while they were at that house in ancient Thebes, for some of them were broken in a way that is hard to explain otherwise. Possibly that is a wild guess, but at any rate there is no doubt of what had happened to them in the little chamber in the tomb on the day of the funeral. After all of the models had been stowed away and the masons had come to brick up the doorway, they had found one of the boats in their way. So one of them picked it up and laid it to one side on top of the granary, and under bow and stern he left a great smear of the mud he had just been mixing for mortar. There those smears still remain.

"The little models had to be parted after all these ages together. Half of them went to the Egyptian government under the terms of our concession, and are now on view in the museum in Cairo. The others can be seen in the Metropolitan Museum in New York."

Mr. Winlock continues in a monograph published by the Museum.

"Only three of the models have anything to do with the tomb or with the funeral. On either side of the chamber stood the statues of two girls dressed in fancifully colored garments, bringing offerings to the tomb—one with a basket of wine jugs and the other with a basket of meats and breads upon her head, and each with a live duck in her hand. They are carved of wood, half-life-size and practically as perfect as the day they were made. Another little group of four figures on a single pedestal represents a priest bringing his censer and libation vase; a man with a pile of bed linen upon his head; and two more girls carrying geese and baskets of food.

"All of the rest of the models pictured the life which Mehenkwetre had lived in this world and the one he expected in the next. Largest and most imposing of all was a model showing the noble at the counting of his cattle. The scene is laid in the courtyard before his house, overlooked by a porch with four brightly colored columns in front. Here he sits with his son and heir squatting on the floor on one side, and four clerks on the other, each busily recording the count on a papyrus roll. On the porch and on the steps stand his butlers and stewards and in the courtyard facing the porch the chief herdsman bows and salutes his lord as he reports. In front there is a waving of sticks and arms as the other herdsmen lead and drive past the beeves—red, black, piebald and speckled. The carving of the little figures, averaging about eight or nine inches high, can scarcely be said to be on a high artistic plane, but there is truth and observation, movements are correctly caught, and with all the brilliancy of the colors there is a cheerfulness that more formal Egyptian works lack.


CARPENTRY IN ANCIENT EGYPT


MILL LASSIES ON THE NILE

MEHENKWETRE, AN EGYPTIAN NOBLE, COUNTING HIS CATTLE—MODEL AS FOUND

"Next in the life history of the ox is the stable where he is fattened. In one room the stall-fed beeves are lined up at the manger; in the other the already fat animals are being fed by hand and one has so nearly got to his limit that he lies upon the floor while a cowherd stuffs food into his mouth. Finally comes the last scene in the slaughter-house. The beeves have been led into a columned hall, two stories high and open to the air high up on one side. They are thrown on the ground and trussed up for butchering; a scribe with pen case and papyrus roll is present to keep the accounts; a head butcher superintends the killing and two men make blood puddings over braziers in the corner. On a balcony at the back the joints of beef 'hang' on lines to ripen.

"The meat supplied, grain foods are next shown. At the granary the ever-present clerks sit in the courtyard with papyrus rolls and tablets keeping the account while two men scoop up the wheat in measures and load it into sacks, and others carry it up the stairs to dump it into three capacious bins. By the front door there sits a boss with cane in hand superintending the work and watching that no one leaves before the time is up. Then cames the bakery and brewery combined in one building. In the first room two women grind the corn into flour and a man makes it into cakes of dough, which another treads into a mash in a barrel. Near by, the rising mash stands in four tall crocks while the yeast ferments, and when it has finished working, another man pours it into a row of stoppered jugs which stand long the wall. In the other room is the bakery. Men are cracking the grain with pestles; women grind the flour; men mix the dough and make fancifully shaped loaves and cakes, which others bake in ovens.

"Handicrafts take up two models. The women spin and weave in one shop and the carpenters ply their trade in another. In the weaving shop three women prepare the flax and put it into buckets for three others who spin it, standing with their distaffs in their left hands and turning their spindles with their right hands against their knees. When the spindles are full they cross to the opposite side of the shop to stretch the newly spun thread out on three pegs on the wall. Meanwhile other women weave cloth on two looms stretched out on the floor. The carpenters' shop is a half-roofed-over court with a furnace for sharpening tools and a tremendous tool chest full of saws, adzes, chisels, and drills beneath the shed. Around the sides of the open court squat gangs of carpenters squaring great timbers with adzes and smooth-surfacing them with blocks of standstone. In the middle of the court a sawyer has lashed a balk of timber upright to a post while he hip-saws it down into boards and another carpenter sits astride of a plank cutting mortise holes in the edge with mortising chisel and mallet.

"Two model gardens were provided for the soul of the great man—models which, so far as our experience of Egyptian antiquities goes, are unique. Just as when we make a child's doll house we leave out lots of details like stairways and put all of our attention on the more important and showy rooms, so the ancient model-maker has devoted all his pains to show only those parts of the house and garden which would most delight the heart of his patron. There is the high wall which shuts out the outside world. Within, a little oblong pool—of copper so that it will hold real water—is surrounded by fruit trees, and facing it is a cool deep porch with gaily painted columns. At the back of the porch a great double state-doorway with a fanlight above, a smaller door for every-day use, and a tall latticed window give a semblance of the façade of the house itself. The trees, made of wood with each little leaf carved and pegged in place, are typical of the naïve realism of all of the models. The fruit is shown, not growing from the twigs but from the main stems and branches so that there shall be no doubt but that the sycamore fig is intended.

"A great man like Mehenkwetre would be required to journey up and down the river to administer his scattered estates and to fulfil his duties in the king's administration. Travel, as always in Egypt, was wholly by boat and a man of high rank would have owned his own vessels for travel and others for pleasure, for the river and the marshes were the playgrounds of the Egyptians. Half the models we found, therefore, are ships and boats to fulfil the needs of Mehenkwetre in a future state which was to be but a repetition of his mortal life. He lived a generation or two before the new cult came into Upper Egypt which required a man to prepare a mystic barge to accompany the Sun on its journeys and it is doubtful whether he even intended any of these boats to represent his funeral float. They are, in fact, models of the every-day ships which plied up and down the river four thousand years ago.

"There are four traveling boats—thirty or forty-footers supposedly, but in the models about four feet long—with crews of from twelve to eighteen sailors besides helmsmen, bowsmen, and captains. Going up river with the prevailing northerly wind, they set a great square sail and we see the little sailors making fast the backstays and hauling on the halyards. Coming down the river with the current against the wind, the mast was lowered in a rest, the sail stowed on the deck, and the crew got out the sweeps. They start their stroke with one foot on the thwart in front and then all together

MODEL OF MEHENKWETRE COUNTING HIS CATTLE—AS RESTORED

heaving on their oars, they end it sitting on the thwarts behind them. On each boat Mehenkwetre sits in his chair at his ease smelling a lotus bud, with his son beside him on one side and a singer on the other patting his mouth with his hand to give his voice a quavering, warbling sound. In one case the singer is accompanied by a blind harper whose harp sits in a little wooden stand between his knees.

"In one cabin sits a stewart as shown in one of our engravings beside a bunk under which are tucked two little round-topped traveling-trunks" [*very much like the old-fashioned "hair trunks" of our great grandfathers.*—EDITOR].

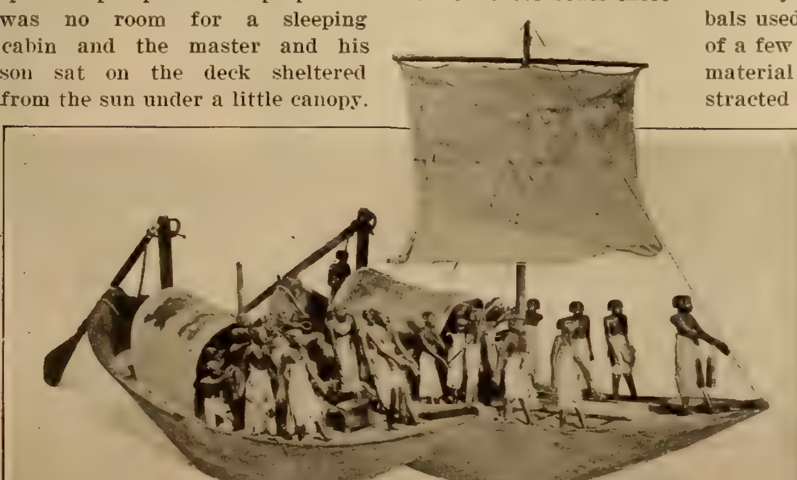
"The river boats of those days were none too large and cooking meals upon them would have been too much of a nuisance for the great man. The kitchen therefore was upon a second boat which followed behind and was moored alongside at meal times. On board women ground flour; men baked—sometimes standing in the dough vat and kneading with their feet while they rolled loaves with their hands; and in the cabins joints of meat were hung up and racks of beer and wine jars were stowed. For shorter trips and pleasure sails there were yachts—long, narrow, green vessels with high curling prows and stems. If the wind was favorable, they stepped the mast and set a square sail like that of the traveling ship. When the wind was contrary, mast and sail were lowered and sixteen members of the crew got out their black, spear-shaped paddles to propel the boat. On these boats there was no room for a sleeping cabin and the master and his son sat on the deck sheltered from the sun under a little canopy.

"For sport there is a little, narrow, light draft skiff for hunting birds and spearing fish in the backwaters. In the bow stand harpooners and the enormous fish struck by one is being landed over the gunwhale. Lashed to the side of the cabin are the poles and stakes for bird nets and a boy and a girl are bringing live ducks which they have caught, to the master and his son who sit on deck. Finally, there are two reed canoes drawing a seine full of fish. Two men paddle each canoe, amidships of which stand the fishermen who haul the net and the helper who lands the fish.

"One great interest of these models is the information they supply on rigging and sailing. In the first place they were originally very complete and accurate and in the second place they are so well preserved that most of them still show ropes and knots intact. For instance, the steering oar can now be studied fully for the first time."

OLD PERSIAN COLONY IN AFRICA

IN the March issue of *Man*, Mr. Ainsworth Dickson describes the only survivals of the regalia of the WaVumba tribe in the delta of the Umba River. They are descendants of a party of Persians who migrated about A.D. 1200 to this district from the plains of Sheraji. About A.D. 1700 the country was swept by a horde of cannibals from the south, and many of the people removed for safety to the adjacent Island of Wassein. The objects now described consist of drums, horns, and cymbals used at the enthronement of a sultan, and with the ruins of a few mosques and some Durbar customs they form the only material evidence of a once-flourishing Persian colony.—Abstracted through *Nature* (London).



A TRAVELING BOAT AND ITS KITCHEN TENDER

SEINE DRAWN BETWEEN TWO CANOES

The Roger Bacon Manuscript

Investigations Into Its History, and the Efforts to Decipher It

By J. Malcolm Bird

DURING the year 1912 Mr. Wilfrid Voynich of New York was traveling through Europe in connection with his business of buying and selling old manuscripts. At an old castle somewhere in northern Italy or southern France he located several large chests, containing an unusual quantity of medieval documents, which had been thus preserved from the collection formed in the eighteenth century by the Dukes of Parma, Ferrara and Modena. It appears that these had been hidden away for safe keeping during the political upheavals of the 1700's or early 1800's, and that their presence and even their existence had been completely forgotten until Mr. Voynich came upon them. He bought some of them, and in view of his expectation of some day going back for the rest, he will not tell any more definitely where they are to be found.

Among the manuscripts of the collection Mr. Voynich noted one that interested him exceedingly, and he made sure that it was in the group he brought away with him. His first casual examination of it, prior to its purchase, was sufficient to make him certain that this manuscript was a product of the thirteenth century. The text would seem to the layman to be Latin, with perhaps some quaint chirography to make its reading more difficult; but to one accustomed to the medieval Latin it is clear that the work is in cipher. It was this fact, taken in consideration with the character of the illustrations found in profusion on every page, that impressed Mr. Voynich. Of these illustrations, some are obviously of astronomic or astrological subjects. The rest are strongly suggestive of an effort to illustrate biological processes, both animal and plant, of some sort. It is entirely obvious that the details are masked behind a heavy veil of symbolism, but Mr. Voynich did not have to take too long a leap in reaching the conclusion that the manuscript dealt with scientific or pseudo-scientific subjects.

AN ASTRONOMICAL PAGE NOT YET "TRANSLATED"

Now a cipher manuscript of a scientific nature from the thirteenth century is on its face a matter of great interest. One cannot refrain from speculating on its authorship. Having thus speculated, one is brought almost automatically to a choice between two possibilities.

It seems reasonable enough to suppose that if this cipher really is of a scientific nature, it constitutes an effort of the scribe to make known to succeeding generations knowledge which he had acquired and which it was unsafe to reveal during his own life. No other reasonable motive for the cipher appears; and this motive is not alone a reasonable one, but one which can be thoroughly justified on historic grounds. If we search the annals of the thirteenth century for men capable of scientific investigation of sufficient originality, and sufficiently free from the petrified scholastic model, to lead to new and dangerous truths, we find that the author might have been Roger Bacon, that he might have been Thomas Aquinas — and that he could hardly by any chance have been anybody else.

On geographic grounds, the manuscript having turned up in southern Europe, we should perhaps be inclined to lean toward the possibility of Aquinas having been the scribe. But when we reflect that our knowledge of the ancient Greek literature is for the most part derived from manuscripts that journeyed to Arabia (in some if not in most cases *via* Rome) and thence to Spain, we must realize that it is a mistake to assume that the works of a given scribe will turn up only within a small radius of his seat of operations. And on every ground other than the geographical one, the probabilities fairly screech the name of Bacon over that of Aquinas.

The Englishman was a rebel against the scholastic learning—a rebel to such an extent that he was continually in hot water with the church government. He was a master of cipher, and is known to have thus cloaked some of the things which he wished to keep from the prying eyes of his superiors. Aquinas, on the other hand, was a most devoted exponent of scholasticism, and if profane knowledge had come into his life he would probably have been the first one to suppress it. It is hardly possible to conceive of the Neapolitan as the author of such a work as we have agreed to assume this one to be;

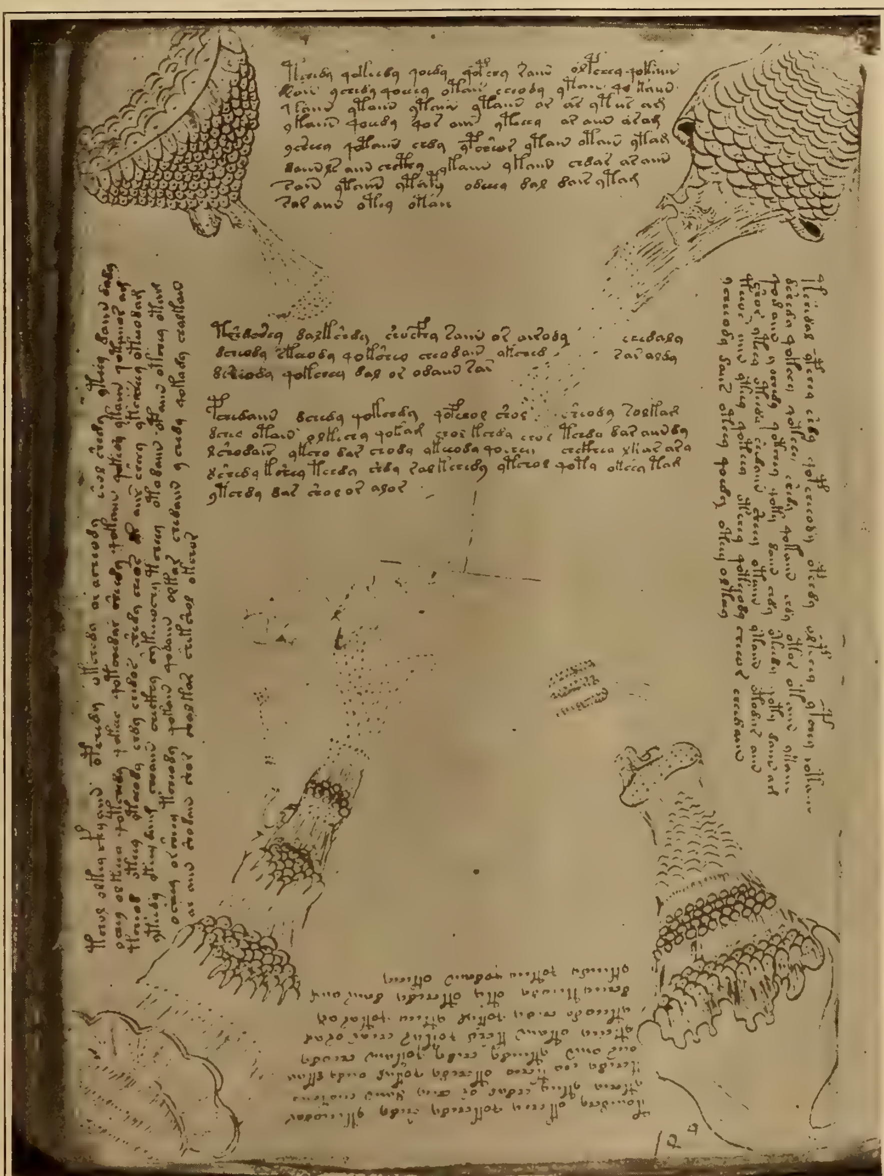
it is almost as difficult to reject the idea that Bacon must have done precisely the thing which we have pictured our unknown scribe as doing. On every ground, the assumption that a thirteen century cipher manuscript of a scientific nature is from his pen is entirely tenable as a working hypothesis.

We cannot allow it to rest as a mere working hypothesis, however; we must exert every endeavor to check it up, to support it as strongly as may be and even to prove it, if this be possible. Such effort will take two directions—the attempt to read the manuscript and thus get either positive testimony or internal evidence with regard to its authorship; and the attempt to trace its history from the time when we picture the scribe as laying it down in Oxford to the time when Mr. Voynich found it somewhere within five hundred miles of the Alps.

For the first of these investigations Mr. Voynich is not qualified, and he has turned the text over to Prof. W. R. Newbold of the University of Pennsylvania. For the business of delving into the certainties, the probabilities and the possibilities of the manuscript's history since its preparation, on the other hand, its owner is about as well equipped as anyone, and to this task he has given his own attention. It is not to be expected that he will be able to produce, for every link of the chain, documentary evidence or other proof that would stand up in a court of law; nevertheless he has made it entirely plausible to suppose that this manuscript may have passed from Oxford to the place where he found it.

The first step was easy. Bound in with the leaves of the manuscript is a letter of presentation from Marcus Marci to Athanasius Kircher. It identifies the manuscript, explains the gift on the ground of Kircher's oft-expressed interest in the document, and alludes to previous ownership of the manuscript by the Emperor Rudolf. This of course is a tremendous stroke of luck—the letter might equally well have contained nothing but the name of donor and recipient, and an expression of their mutual regard.

Marci and Kircher are both known figures. Marci had been president of the University of Prag, which to all intents and purposes was the capital of Rudolf's empire, rather than Vienna. For Rudolf was a bookish king, far more interested in literary pursuits than in matters of state; and such pursuits naturally centered in Prag rather than in Vienna. Kircher was a Jesuit scholar of some note, known to have been long intimate with the Parmese ducal family. His established ownership of the manuscript, and its subsequent appearance in the ducal collection, leaves little room for doubt that he made it over to the Duke of his period—perhaps in his will, perhaps during his lifetime.



A TYPICAL PAGE OF DRAWINGS WHICH ARE SUPPOSED TO BE OF A BIOLOGICAL CHARACTER

Here it is presumed that we have stages in the reproduction of plants from seed.

By another stroke of fortune it became possible to account adequately for Marci's possession of the manuscript. The details of the text, faded as they were with age, were difficult to make out. Photostatic reproduction with long exposures was tried, with the hope that it would act, like astronomical photography, to bring out markings which were not clear enough to make instantaneous impression on the eye, as they must to be seen at all. The effort was successful; and among the things which it revealed was a fragmentary signature on one of the pages, which was identified as that of Jacobus Horcicky de Tepeneez. The proud possessor of all this name was quite a famous botanist, and held the post of director of Rudolf's chemical laboratory. An interesting sidelight which goes to indicate that human nature is substantially constant may be seen in the fact that de Tepeneez accumulated a huge fortune through the sale of eau de cologne as a universal remedy.

The botanist could hardly have attached his signature to the manuscript unless it had been his property. Independent documentary evidence is available which indicates that the Emperor loaned him the manuscript, not long before his (Rudolf's) death. Mr. Voynich reminds us that after this event the great collection of manuscripts and other scientific material amassed by Rudolf was dispersed, quite informally—which is to say, everybody helped himself to whatever he wanted. The assumption seems a fairly reasonable one that de Tepeneez decided that he wanted the mysterious cipher manuscript worse than anyone else, and made a mental transfer of its ownership from the imperial estate, in which nobody had any particular interest, to himself.

There is no direct evidence indicating where Rudolf got the manuscript, but there is indirect evidence that it is not easy

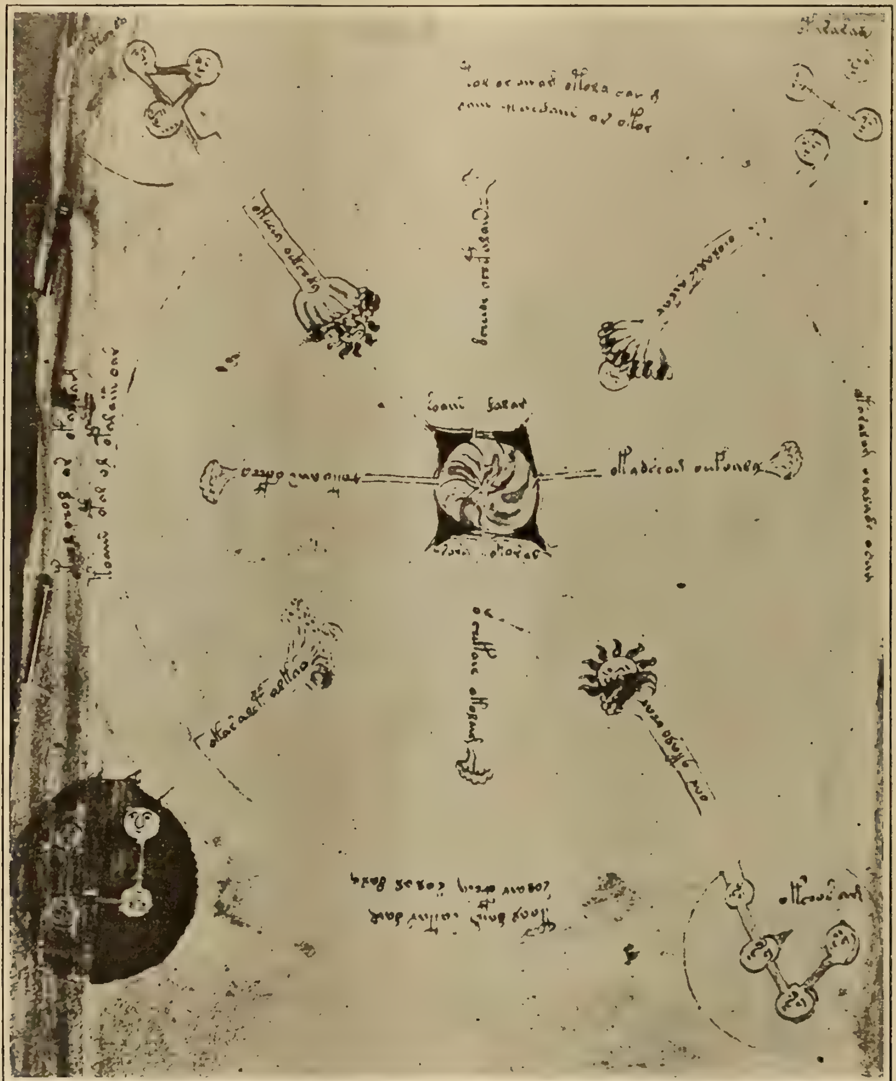
to reject. One of Rudolf's courtiers in a letter tells us that it was brought to him (from a place not stated) by a messenger (identity not stated), who received no less a reward than the prodigious sum of 600 imperial ducats. Mr. Voynich has investigated very closely the hangers-on of Rudolf's establismment and the visitors thereto, and believes he has identified the man who brought him the cipher work.

John Dee was an English scholar, born in 1527, and died in 1608. Like so many of his contemporaries, Dee combined learning with politics, and was for many years in favor at the court of Elizabeth. In particular he acted, on more than one occasion, as her envoy or special messenger to Rudolf in Prag. This of itself would be far from conclusive—presumably there were other Englishmen of the period who went to Prag once, or twice, or even more often. But the interesting feature of Dee's visits is that he was a tremendous Bacon enthusiast. He had a collection of Bacon manuscripts exceeding anything before or since—the largest accumulation of these ever got together. On the continent, where Bacon's name and fame had gone into eclipse because of the prevailing orthodox Catholicism of these countries, Dee is known to have definitely revived interest in his work to such an extent that one of Rudolf's scientific satellites was proud to bear the designation "The Lesser Bacon." In view of Dee's great preoccupation with Baconia and the known fact that he went as a confidential messenger to Rudolf on several occasions, Mr. Voynich's conclusion that he was the mysterious messenger who brought him the cipher manuscript seems sufficiently reasonable to stand up under fire.

Dee's known possession of a huge number of Bacon manuscripts is of course a great point in support of this contention. Just where he got these, and in particular the one in which we are interested, does not clearly appear. He was acquainted with the ducal house of Northumberland, and it was through this channel that he got the foundation for his collection, adding to it independently later. There seems no ground for hoping that his source for this one manuscript can ever be identified.

It appears therefore that an entirely reasonable chain of ownership can be exhibited running from a man who is known to have owned practically all the Bacon manuscripts that exist, to a man who is known to have owned this particular manuscript. No absolute proof to speak of is offered, but an entirely plausible history for the manuscript running from, say, 1550 to the present moment has been indicated. This is of particular bearing in that it accounts so satisfactorily for the transfer of the document, first from Oxford to Prag, and later to Parma. While not proof, it comes about as close to being proof as we can usually hope to come in the case of a medieval manuscript that has passed through private ownership.

With this side of the matter disposed of to our satisfaction we may turn to the problem of translation. Professor Newbold assures us that this is a task of extraordinary difficulty—so much so that he doubts that the manuscript will ever be read, in its entirety, with scientific accuracy. In any event it is a labor for many years and numerous hands. He believes he has succeeded in driving the entering wedge, to the extent of learning the general principles governing the cipher used; and that he has applied these principles in translating the text, with a degree of success that justifies their acceptance.

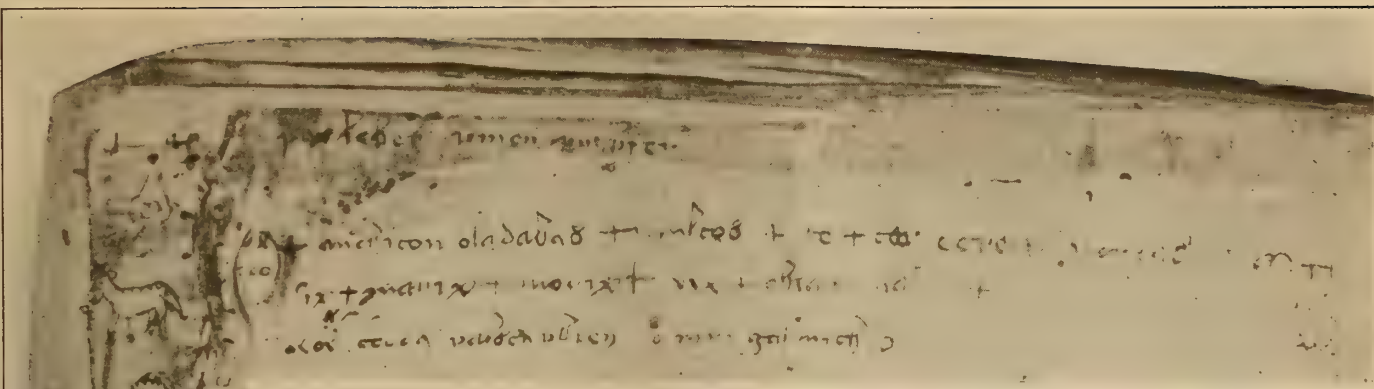


THE PAGE ON WHICH THE STATEMENT OF THE ANNULAR ECLIPSE OCCURS
The central drawing is taken to be a representation of this eclipse; the significance of the others is not apparent.

The last page of the manuscript, according to Professor Newbold, offers the key to the situation. It is unillustrated, while all the other pages are freely adorned with the drawings to which we have referred; and instead of being a full page, it consists of but two or three lines near the top of the sheet. It is entirely reasonable to suppose that it is not actually a part of the manuscript, but that it represents a memorandum of some sort. It is, however, by the scribe, and not by a later owner. It is therefore again reasonable to suppose that it has something to do with the cipher.

A careful inspection of this memorandum shows that it consists in part of the sentence, which looks somewhat like Latin and somewhat like nonsense, "michiton oladabas multos te fccr cerc portas." Supplying a preposition in place of the chewed-off corner of the manuscript, and dropping so much of this inscription as is on its face nonsensical, Professor Newbold finds that the rest shakes down to the sentence "A mihi dabas multos portas." In spite of the disagreement between multos and portas, he decided that it meant what it must mean if it means anything—"Thou hast given me many gates," and that in some way this was a key sentence to the cipher.

Professor Newbold has a wide acquaintance with ciphers, but



LINES ON THE LAST PAGE OF THE MANUSCRIPT IDENTIFIED BY PROFESSOR NEWBOLD AS A PARTIAL KEY TO ITS DECIPHERMENT

was unable to make the present one look like any with which he is familiar. He finally reached the conclusion that it was a compound cipher, employing different systems in such a manner that in decipherment he would have to unravel each step separately, no combination of the several steps into a single resultant step being possible. Later he concluded that the final step of the encipherment had been the reduction of the Roman letters of the message to a short-hand of some sort. He finally satisfied himself that he had identified this system, fifteen of the characters being taken from a known short-hand system of the ancient Greeks, and the other seven, which he succeeded in identifying, having apparently been of the scribe's own invention.

The nature of this short-hand is quite extraordinary. The several signs consist of minute marks, gradations and shadings which can be incorporated into the ordinary letters, a number of them in each letter at the same time, in fact. They have to be read with a glass of some sort. The variation of one-fiftieth part of an inch, says Professor Newbold, makes all the difference between one sign and another. Practicable on vellum, he believes the system could not be used on paper, with its fibers that would appear as marks on the surface and be confused with the marks of the cipher.

After the apparent letters of the text have been replaced, using the short-hand key, by the letters for which they stand, the text will have been e x p a n d e d to considerably more than twelve times its original bulk—few of the letters consist of less than this number of individual characters, many of them contain more. A single word of seven letters in the text, which Professor Newbold used for demonstration purposes, he broke down into 172 Roman letters.

The second step consists in grouping the letters thus derived into pairs, supplying a duplicate of each letter so that the pairs interlock. An example will make the process clearer than any amount of explanation could hope to make it. The word "cipher," treated after this scheme, would become five letter-pairs, thus: ci, ip, ph, he, er.

The third and fourth steps in the decipherment consist in substitutions for these letter-pairs—first a substitution which converts each pair into another pair, then another substitution changing each of the new pairs back into a single letter. Professor Newbold has not in any of his public utterances explained satisfactorily how, in the original encipherment, it is possible to bring it about, as the result of the inverse substitutions, that we should get letter-pairs that interlock as in the above example. Certainly if we take an arbitrary series of single letters, say, "abcdefg," and substitute for each letter a pair of letters, then for each pair another pair, it does not seem as though we could, in general, anticipate that any such interlocking arrangement would hold. This would indicate that, if Professor Newbold really has hit upon a valid scheme for decipherment, he does not actually reverse the original steps of encipherment, but employs a process, presumably more complicated, which turns out to give the same result. In a single-step cipher this could hardly occur, but in a cipher of six stages, as this one is stated to be, we should think that a result of this character would be about as probable as direct solution by actual reversal of the enciphering processes.

PHOTOGRAPH OF THE GREAT SPIRAL NEBULA OF ANDROMEDA

Because of the inclination of its plane with respect to our line of vision its spiral form is not evident except as viewed through a powerful telescope

The fifth and sixth stages of the decipherment process are those which will stick hardest in the throat of layman and mathematician alike. The one consists in a substitution which follows no fixed rule but is more or less arbitrary; the other in a rearrangement, at pleasure, of the letters resulting from the fifth step, so that they shall make up words. Professor Newbold tries to reassure us here by telling us that he considers no passage successfully translated until he has effected such an anagrammatic readjustment which shall use up all the letters and make sense. Our only comment upon this is that we should hope he would concede this much to the critics, at the very least, without boasting about it. Indeed, in the absence of definite information as to just how large a section of the original Professor Newbold shakes up in his anagram machine at one operation, there is little more to

say. If only a score or so of letters, he of course can exhaust the possibilities and show that no other arrangement is possible. If he allows himself a greater latitude he cannot always do this. Again, if he employs a consistent and constant method of deciding just how much text to include in each of his shufflings, he is on better ground than if he takes as much as he needs to get letters which he can twist into sensible Latin.

It will be inferred from this account that the writer is not enthusiastic about Professor Newbold's translation. Professor Newbold himself admits the serious ambiguity of his process; he states explicitly that at two stages of the decipherment the indeterminate element enters so strongly that there is presented the necessity for exercising what he calls "judgment." We have another and slightly less impressive word for this—it is "guessing." Unless the guessing can be eliminated, we do not regard Professor Newbold's claims that he has translated the cipher as warranted.

As a matter of fact, Professor Newbold realizes this himself, we believe. For one thing, he emphasizes that the translated text and the picture ought to harmonize. This is true enough, but we are surprised that it is urged in favor of the "decipherment." For in practically every case where "decipherment" has yet been effected, the picture is such as to suggest quite strongly, not perhaps what the text should say in order to harmonize, but at least what it should talk about. Guessing with a guide, even one which is followed unconsciously and without evil intent, is not the same as just guessing; the result at once begins to depend upon the guide as well as upon the guesser.

In at least two cases Professor Newbold has scored what he puts forward as a notable triumph. One of the drawings was submitted to an astronomer for an opinion as to what it represented; the verdict was that it unquestionably was a crude effort to draw a spiral nebula. After much work on the caption of this drawing—that is to say, upon what a modern editor would call its caption—Professor Newbold evolved out of it a statement that, using a refracting mirror, the scribe had seen, at a point in the heavens which he identifies in terms of the Navel of Pegasus and other ancient marks, a star shaped like a snail shell. His localization of this apparition is a very good amateur attempt to describe the position of the Great Nebula of Andromeda. This page is the basis for the claim that Bacon discovered the telescope.

In another case we have a drawing, reproduced herewith, which we think will be agreed to have strong astronomical leanings. The translator found in connection with this the statement that the observer had seen what he described in terms showing clearly that he is talking about an annular eclipse; and the date of the observation is given. Checking up by the department of astronomy verified this date (in the thirteenth century, of course) as that of an annular eclipse. And when we have had it suggested to us, we can see that there are things which the drawing resembles less than it does an annular eclipse.

Professor Newbold states that in both cases he was quite without the knowledge in point until he had read it in the manuscript. Leaving quite aside the question of his good faith, we wonder whether he is sure of this. He has done a vast amount of reading in connection with medieval manuscripts and medieval lore in general. It is not for a moment to be supposed that he consciously remembers everything that he has ever thus read. In view of the mathematical probabilities inherent in the methods of decipherment which he permits himself, we consider it at least equally likely that something which he has read has cropped up subconsciously and influenced his translation, as that he has really reproduced the words of his original.

As a matter of fact, in the case of the Andromeda nebula, the translator is sufficiently out of luck to suggest strongly that this is what has happened. The ordinary spiral nebula does look much like a snail shell, and might very likely be thus described by one seeing it for the first time; and the Andromeda nebula is a spiral one. But it just happens that we are looking at this nebula almost due edgewise, so that the spiral effect is greatly masked by perspective; our photograph shows this clearly. We have the gravest doubt that anyone not thoroughly acquainted with spiral nebulæ and star clusters would ever identify this object as of the former rather than the latter class, or ever see a snail-shell effect in it. And when Professor Newbold's colleagues of the department of astronomy assure him that Bacon couldn't have seen this nebula as a spiral—even as so much of a spiral as our picture reveals it to be—without a telescope, they are putting it mildly; they might equally have said that he couldn't have recognized this feature of it without a telescope of decidedly high power.

We are rather inclined to accept the manuscript as from Bacon. Until further progress is made, and in the expectation that further progress, if it is made, will result in the further rationalizing of some of the steps of decipherment, we are not prepared to accept the translation. Professor McClung, when called upon to substantiate the claims of Professor Newbold that certain of the drawings possessed certain biological significance, came as close to flat contradiction of this possibility as the courtesies of the occasion permitted. He did flatly contradict it, so far as his own judgment was concerned, in seven out of nine exhibits; in the other two he was not so certain but it was plain that he felt the symbolism of the drawings to be so excessive that no objective representation could properly be claimed for them. Our state of mind with regard to the cipher rendition is about the same as his with regard to the drawings. The manuscript and the efforts to read it are of extraordinary interest; but we do not consider that definite statements of results should have been made at the present stage.

It will be remembered that the Shakespeare-(Francis) Bacon cipher possessed an indeterminate element, in that the reader might look in a large number of places for the next letter. The enthusiasm of those who claimed that Shakespeare didn't write the plays waned noticeably when some mathematically inclined gentleman—was it the astronomer, Proctor, in the remarkable paper, "Knowledge," which he edited for some years?—showed that with the freedom of judgment exercised, the probabilities were many millions to one that the desired message could be found. When Professor Newbold incorporates two indeterminate steps into his decipherment, he does not seem to be on any better ground than the lamented Ignatius Donnelly.

TREPHINING AMONG THE PREHISTORIC INDIANS

TREPHINING was of common occurrence among prehistoric Indians of South America, and is still practised in Bolivia and Peru. Where stones from slings, the "bola" or "lliui" and wooden clubs with heads of stone and copper were the common offensive weapons, complex fracture of the skull with depression of the bony plates must have been very common. A fracture of the skull sometimes resulted in almost instant death, but many victims survived wounds of this sort, and an attempt to remove splinters of bone that pricked the brain, or to cut out fragments that pressed upon it, must have become, at an early date, a natural procedure.

To the American Museum of Natural History belongs credit for investigations in Peru and Bolivia which revealed much interesting information as to ancient pathology and surgical practices in these regions. Of nearly 1,200 skulls collected on one Museum expedition in Bolivia, conducted by the late Dr. Adolph Bandelier, about 5 per cent of the skulls had been trephined. The members of the party discovered, furthermore, that trephining is practised in Bolivia today, by medicine men. The operation is performed with any available cutting instrument, and the process is one of incision and scraping.

The Indians apply "coca" to wounds, bruises and contusions for healing purposes, and it tends to deaden pain.

GRADUATED TILES WHICH GIVE A ROOF A MORE EXTENSIVE APPEARANCE

Visual Illusions in the Arts*

Tricks of Lighting, Color and Form for Painters, Sculptors and Architects

By M. Luckiesh

IN the arts where colors, brightnesses, contrasts, lines, forms, and perspectives mean so much, it is obvious that visual illusions are important. Sometimes they are evils which must be suppressed; in some cases they are boons to the artist if he is equal to the task of harnessing them. Ofttimes they appear unheralded and unexpected. The existence of visual illusions is sufficient to justify the artist's pride in his "eye" and his dependence upon his visual judgment rather than upon what he knows to be true. However, true this may be, knowledge is useful to the artist as it is to any one else. The artist, if he is to produce art, is confronted with the tremendous task of perfecting an imperfect nature and he is handicapped with tools inferior to those which Nature has at her disposal. He must deal with reflected lights from earthly materials. Nature has these besides the great primary light-sources—the sun, the moon, the stars, and, we might say, the sky. She also has the advantage of overwhelming magnitudes.

A painting in the broadest sense is an illusion for it strives to present the three-dimensional world upon plane areas of two dimensions. Through representation or imitation it creates an illusion. If the artist's sensibility has been capable of adequate selection, his art will transmit by means of and through the truths of science, from the region of perception to the region of emotion. Science consists of knowing; art consists of doing. If the artist is familiar with the facts of light, color, lighting, and vision, he will possess knowledge that can aid him in overcoming the great obstacles which are ever-present.

The artist may suggest brilliant sunlight by means of deep shadow. The old painters gained color at the expense of light and therefore lowered the scale of color in their representations of nature. It is interesting to see how increasing knowledge, as centuries passed, directed painters as it did others onward toward the truth. Turner was one of the first to abandon the older methods in an attempt to raise the scale of his paintings toward a brilliance more resembling nature. By doing this he was able to put color in shadows as well as in lights. Gradually paintings became more brilliant. Monet, Claude, and others worked toward this goal until the brightnesses of paintings reached the limits of pigments. The impressionists in their desire to paint nature's light introduced something which was nothing more nor less than science. All this time the true creative artist was introducing science—in fact, illusions—to produce the perfect illusion which was his goal.

In the earliest art, in the efforts of children, in the wall-paintings of the Egyptians, and in Japanese representation of nature, the process is selective and not imitative. Certain things are chosen and everything else is discarded. In such art selection is carried to the extreme. Much of this simplicity was due to a lack of knowledge. Light and shade, or shading, was not introduced until science discovered and organized its facts. Quite in the same manner linear and aerial perspective made their appearances until in our present art the process of selection is complex. In our paintings of today objects are modeled by light and shade; they are related by perspective; backgrounds and surroundings are carefully considered; the proper emphasis of light, shade and color are given to certain details.

The painter can imitate aerial perspective although many centuries elapsed before mankind was keen enough to note its presence in nature. The atmospheric haze diminishes the brightness of very bright objects and increases that of dark objects. It blurs the distant details and adds a tinge of blue or violet to the distance. In painting it is a powerful illusion which the painter has learned to employ.

The painter can accurately imitate mathematical or linear perspective but the art of early centuries does not exhibit this feature. In a painting a tremendously powerful illusion of

*Excerpts from a forthcoming book by the author on "Visual Illusions."

the third dimension is obtained by diminishing the size of objects as they are represented in the distance. Converging lines and the other manifold details of perspective are aiding the artist in his efforts toward the production of the great illusion of painting.

The painter cannot imitate focal perspective or binocular perspective. He can try to imitate the definition in the central portion of the visual field and the increased blurring toward the periphery. Focal perspective is not of much importance in painting because it is scarcely perceptible at the distances

FIG. 1. EFFECTS OF GRAIN IN A PICTURE FRAME
The horizontal sides appear bowed up in the middle and the vertical sides bowed to the right

at which paintings are usually viewed. However the absence of binocular perspective in painting does decrease the effectiveness of the illusion very markedly. For this reason a painting is a more successful illusion when viewed with one eye than with two eyes. Of course, in one of nature's scenes the converse is true because when viewing it with both eyes all the forms of perspective coöperate to the final end—the true impression of three dimensions.

The painter may imitate the light and shade of solid forms and thereby apparently model them. In this respect a remarkable illusion of solid form or of depth may be obtained. For example, a painted column may be made to appear circular in cross-section or a circle when properly shaded will appear to be a sphere. Both of these, of course, are pure illusions. Some stage paintings are remarkable illusions of depth and their success depends chiefly upon linear perspective and shadows.

The inadequacy of the range of brightnesses or values obtainable by means of pigments is not fully realized by the artist. The sky in a landscape may be thousands of times brighter than a deep shadow or a hole in the ground. A cumulus cloud in the sky may be a hundred thousand times brighter than the deepest shadow. However, the artist must represent a landscape by means of a palette whose white is only about thirty times brighter than its black. If the sun is considered we may have in a landscape a range of brightness represented by millions.

This illustrates the pitiable weakness of pigments alone as representative media. Will not light *transmitted* through media some day be utilized to overcome this inherent handicap of reflecting media? The range of brightness in this case may be represented by a black (non-transmitting) portion to the brightness of the background (artificial or sky) as seen through an area of clear glass.

It is interesting to study the effect of greatly increasing the range of values or brightnesses in paintings by utilizing non-uniform distributions of light. Let us take a given landscape painting. If a light-source be so placed that it is close to the brighter areas (perhaps clouds and sky near the sun) it will illuminate this brighter portion several times more intensely than the more distant darker portions of the picture (foreground of trees, underbrush, deep shadows, etc.). The addition to the effectiveness of the illusion is quite perceptible. This effect of non-uniform lighting may be carried to the extreme for a painting by making a positive lantern-slide (rather contrasty) of the painting and projecting this slide upon the painting in accurate superposition. Now if the painting is illuminated solely by the "lantern-slide" the range of contrast or brightness will be enormously increased. The lightest portions of the picture will now be illuminated by light passing through the almost totally transparent portions, and the darkest parts by light greatly reduced by passing through the nearly opaque portions of the slide. The original range of contrast in the painting, perhaps twenty to one is now increased perhaps to more than a thousand to one.

Many tricks may be interjected into the foreground of a painting for their effect upon the background and vice versa. For example, a branch of a tree drooping in the foreground apparently close to the observer, if done well will give a remarkable depth to a painting. Modeling of form may be effected to some extent by a judicious use of the "retiring" and "advancing" colors. This is one way to obtain the illusion of depth.

After-images play many subtle parts in painting. For example, in a painting where a gray-blue sky meets the horizon of a blue-green body of water, the involuntary eye-movements may produce a pinkish line just above the horizon. This is the after-image of the blue-green water creeping upward by eye-movements. Many vivid illusions of this character may be deliberately obtained by the artist. Some of the peculiarly restless effects obtained in impressionistic painting (stippling of small areas with relatively pure hues) are due to contrasts and after-images.

There are many interesting effects obtainable by judicious experimentation. For example, if a gray medium be sprayed upon a landscape in such a manner that the material dries in a very rough or diffusing surface some remarkable effects of fog and haze may be produced. While experimenting in this manner a very finely etched clear glass was placed over a landscape and the combined effect of diffusely reflected light and of the slight blurring was remarkable. By separating the etched glass from the painting a slight distance a very good imitation "porcelain" was produced. The optical properties of varnishes vary and their effect varies considerably, depending upon the mode of application.

All the means for success which the painter possesses are also available to the decorator; however, the latter may utilize some of the illusions of line, form, irradiation, etc., which the architect encounters. The decorator's field may be considered to include almost all of the painter's and much of the architect's. The decorator should begin to realize more

FIG. 2. THE GRAIN MAKES THE FRAME LOOK NARROWER AT THE LEFT THAN AT THE RIGHT

fully the great potentiality of lighting in creating moods or in giving expression to an interior. The psychology of light and the use of lighting as a mode of expression have barely been drawn upon by the decorator.

The practice of hanging pictures on walls which are brilliantly colored is open to criticism. The changes in the appearance of the object due to these highly colored environments are easily demonstrated by viewing a piece of white

paper pinned upon the wall. On a green wall the white paper appears pinkish; on a rose wall it appears bluish or greenish. A portrait or a picture in which there are areas of white or delicate tints is subject to considerable distortions in the appearance of its colors. Similarly, if a woman must have a colored background, it is well to choose one which will induce the more desirable tints in her appearance. The designer of gowns certainly must recognize these illusions of color which may be desirable or undesirable.

The quality of the light (its spectral character) may have an enormous influence upon the painting. In fact with the same painting many illusions may be produced by lighting. In general, paintings are painted in daylight and they are not the same in appearance under ordinary artificial light. For this reason the artist is usually entitled to the preservation of the illusion as he completed it. By using artifical daylight,

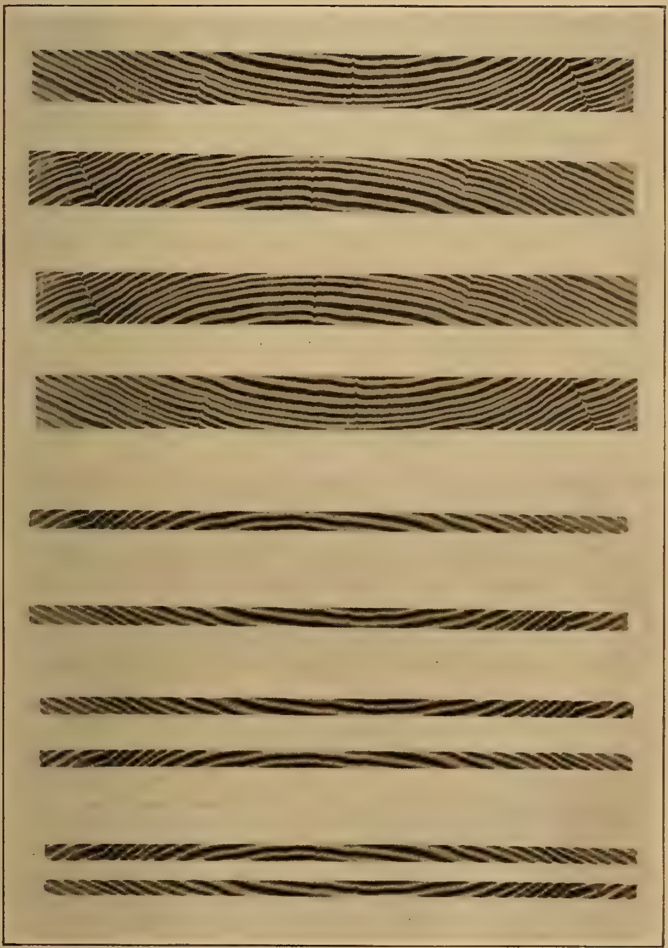


FIG. 3. VARIOUS DEGREES OF APPARENT WARPING DUE TO GRAIN

which has been available for some years, the painting appears as the artist gave it his last touch. Of course it is quite legitimate to vary the quality of light in case the owner desires to do so but the purpose here is to emphasize the fact that the quality of light is a powerful influence upon the appearance of the painting. The influence is not generally enough recognized and its magnitude is appreciated by relatively few persons.

All other considerations aside, a painting is best hung upon a colorless background and black velvet for this purpose yields remarkable results. Gray velvet is better, when the appearance of the room is taken into consideration, as it must be. However, the influence of dark surroundings toward enhancing the illusion is well worth recognizing. In the case of a special picture or a special occasion, a painting may be exhibited in a booth—a huge shadow-box not unlike a show-window in which the light-sources are concealed.

Incidentally on viewing some picture frames in which the grain of the wood was noticeable, the frames did not appear to be strictly rectangular. The illusions were so strong that only by measuring the frames could one be convinced that they were truly rectangular and possessed straight sides. Two of these are represented in Figs. 1 and 2. In the former the horizontal sides appear bent upward in the middle and the two vertical sides appear bowed toward the right. In Fig. 2 the frame appears considerably narrower at the left end than at the right. Both these frames were represented in the original drawings by true rectangles.

Many illusions are to be seen in furniture and in other woodwork in which the grain is conspicuous. This appears to the author to be an objection in general to this kind of finish. In Fig. 3 there is reproduced a photograph of the end of a board which was plane or straight notwithstanding its warped or bowed appearance. The original photographs were placed so as to be related as shown in the figure. Various degrees of the illusion are evident. The reader will perhaps find it necessary to convince himself of the straightness of the horizontal edges by applying a straight edge.

Many illusions are found in architecture and, strangely enough, many of these were recognized long before painting developed beyond its primitive stages. The architecture of classic Greece displays a highly developed knowledge of many geometrical illusions and the architects of those far-off centuries carefully worked out details for counteracting them. Drawings reveal many illusions to the architect but many

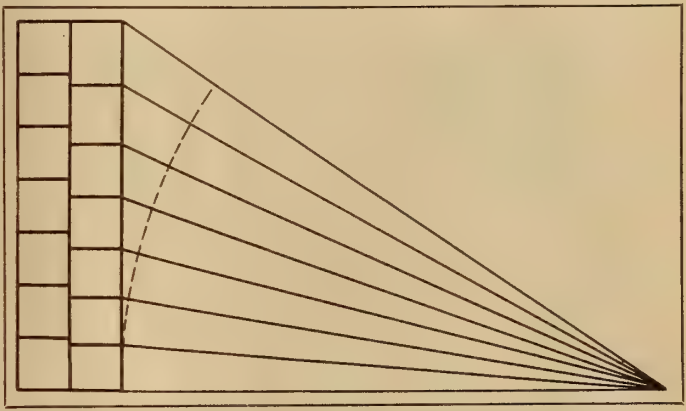


FIG. 4. DIAGRAM ILLUSTRATING WHY THE STORIES OF A BUILDING SHOULD INCREASE IN HEIGHT FROM THE GROUND UP IF THEY ARE TO APPEAR OF EQUAL SIZE

are not predicted by them. The ever-changing relations of lines and forms in architecture as we vary our viewpoint introduce many illusions which may appear and disappear. No view of a group of buildings or of the components of a single structure can be free from optical illusions. We never see in the reality the same relations of lines, forms, colors, and brightnesses as indicated by the drawings or blue-prints. Perhaps this is one of the best reasons for justifying the construction of expensive models of our more pretentious structures.

In architecture the eye cannot be wholly satisfied by such tools as the level, the square, and the plumb-line. The eye is satisfied only when the *appearance* is satisfactory. For the purpose of showing certain architectural illusions, the compensatory measures applied by the Greeks are excellent examples. These also reveal the remarkable application of science to architecture as compared with the scanty application in painting of the same period.

During the best period of Grecian art many refinements were applied in order to correct optical illusions. The Parthenon of Athens affords an excellent example of the magnitude of the corrections which the designer thought necessary in order to satisfy the eye. The long lines of the architrave—the beam which surmounts the columns or extends from column to column—would appear to sag if it were actually straight. This is also true of the stylobate, or substructure

of a colonnade, and of pediments and other features. These lines were often convex instead of being straight as the eye desires to see them.

In the Parthenon, the stylobate has an upward curvature of more than four inches on the sides of the edifice and of more than two and a half inches on the east and west fronts. Vertical features were made to incline inward in order to correct the common appearance of leaning outward at the top. In the Parthenon the axes of the columns are not vertical but they are inclined inward nearly three inches. They are said also to be inclined toward each other to such a degree that they would meet at an altitude of one mile above the ground. The eleven-foot frieze and architrave is inclined inward about one and one-half inches.

In Fig. 6 *a* represents the front of a temple as it should appear; *b* represents its appearance (exaggerated) if it were actually built like *a* without compensations for optical illusions; *c* represents it as built and showing the physical corrections (exaggerated) in order that it may appear to the eye as *a* does.

Tall columns if they are actually straight are likely to appear somewhat shrunken in the middle; therefore they are sometimes made slightly swollen in order to appear straight. This outward curvature of the profile is termed an entasis and in the Parthenon column, which is thirty-four feet in height, amounts to about three-fourths of an inch. In some early Grecian works it is said that this correction was overdone but that its omission entirely is quite unsatisfactory. Some authorities appear to believe that an excellent compromise is found in the Parthenon columns.

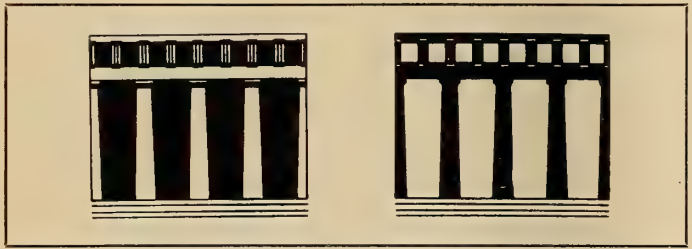


FIG. 5. COLUMNS VIEWED AGAINST THE SKY LOOK LARGER THAN WHEN VIEWED AGAINST A DARK BACKGROUND

One of the conditions which is responsible for certain illusions and has been compensated for on occasions is represented in Fig. 5. On the left are a series of squares of equal size placed in a vertical row. If these are large so that they might represent stories in a building they will appear to decrease in size from the bottom upward, because of the decreasing projection at the eye. This is obvious if the eye is considered to be at the point where the inclined lines meet. In order to compensate for the variation in visual angle, there must be a series of rectangles increasing considerably in height toward the top. The correction is shown in the illustration. It has been stated that an inscription on an ancient temple was written in letters arranged vertically and in order to make them appear of equal size, they were actually increased in size toward the top according to the law represented in Fig. 4. Obviously a given correction would be correct only for one distance in a given plane.

The phenomenon of irradiation exerts its influence in the arts as elsewhere. For example, columns viewed against a background of white sky appear of smaller diameter than when they are viewed against a dark background. This is illustrated in Fig. 5 where the white and the black columns are supposed to be equal in diameter.

The careful observer will find numberless optical illusions and occasionally he will recognize an attempt on the part of the architect to apply an illusory effect to his advantage.

If a high wall ends in a series of long horizontal steps at a slightly inclined sidewalk, the steps are not likely to appear horizontal.

Some remarkable illusions of depth or of solid form are given to flat surfaces when snow is driven against it so as to adhere in decreasing amounts similar to shading.

A suggestion of augmented height may be given to a low tower by decreasing the size of its successive portions more rapidly than demanded by perspective alone. The same principle can be applied in many ways. For example, the roof in the photograph shown on page 498 looks very extensive particularly if viewed in such a position that the end-walls of the structure are not seen. Such illusions find applications in the moving-picture studio where extensive interiors, great fortresses, and even villages must be erected within small areas. Incidentally the camera aids to create the illusion of magnitude in photographs because it usually magnifies perspective thereby causing scenes to appear more extensive in the photographs than in the reality.

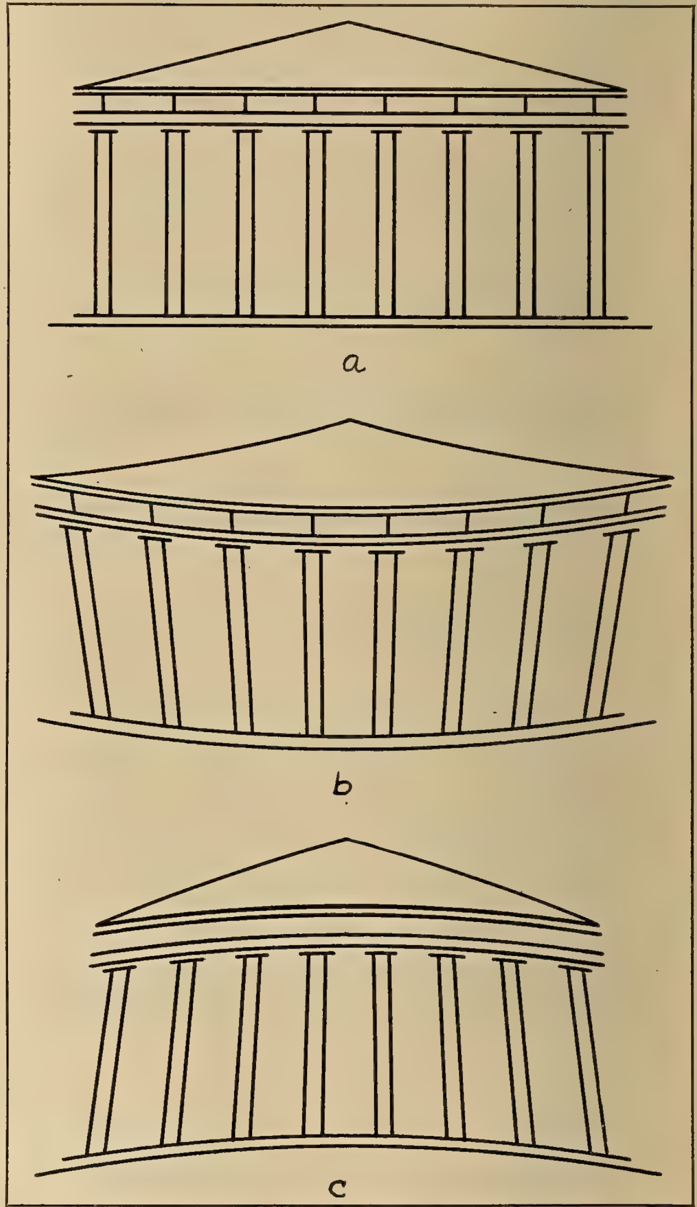


FIG. 6. ARCHITECTURAL ILLUSIONS

a, Front of temple as it should appear; *b*, appearance (exaggerated) if built like *a* without compensation for optical illusions; *c*, physical corrections (exaggerated) in order that it may appear as *a* does.

Balance in architecture is subject to illusions and might be considered an illusion itself. For example, our judgment of balance is based somewhat upon mechanical laws. A composition must appear to be stable; that is, a large component such as a tower must not be situated too far from what we take as a center of gravity, to appear capable of tipping the remainder of the structure. In physics we would apply the term "moment." Each mass may be multiplied by its dis-

tance from the center of gravity, thus determining its moment. For a building or other composition to appear stable the sum of these moments must be zero; that is those tending to turn the figure in one direction must be counterbalanced by those tending to turn it in another direction. In appraising a composition, our intellect summates the effects of different parts somewhat in this manner and if satisfactory, balance is considered to have been attained. The colors of the various components exert an influence in this respect so it is seen that illusions may have much to do with the satisfactoriness of architectural compositions.

Various illusions of height of ceiling, composedness, etc., may be obtained by the color and brightness of the ceiling. A dark cornice in an interior may appear to be unsupported if the walls below are light in color, without any apparent vertical supports for the cornice. We are then subjected to the illusion of instability or incongruity. Dark beams of ceilings are not so obtrusive because our intellect tells us that they are supports passing over the top of the walls and are therefore able to support themselves. Color and brightness in such cases are very important.

The architectural details on exteriors evolved under daylighting outdoors so that their form has been determined by the shadows desired. The architect leads his lights and shadows around the building modeling it as he desires. An offset here and a depression there models the exterior in light and shade. The forms must be powerful enough to resist the obliterating effect of overcast skies but notwithstanding all precautions the expression of an exterior varies considerably with nature's lighting. Indoors the architect has a powerful controllable medium in artificial light which he may draw upon for producing various expressions or moods in rooms. The effect of shadows is interesting when viewing some structures flood-lighted at night. In those cases where the light is directed upward there is a reversal of shadows which is sometimes very unsatisfactory.

It is interesting to experiment with various ornamental objects lighted from various directions. For example, a Corinthian capital lighted from below may produce an unpleasant impression upon the observer. We do not like to have the dominant light from below perhaps because it is annoying to the eyes. Possibly this is an instinct acquired by experience in snow-fields or on the desert, or it may be a heritage of ancestral experience gained under these glaring conditions. This dislike manifests itself when we appraise shadow-effects and therefore our final impression is tempered by it.

All sculptured objects depend for their appearance upon the lighting, and they are greatly influenced by it. In sculpture, in a strict sense, illusions play a lesser part than in other arts. Perhaps in those of very large proportions various corrections have been applied. A minor detail of interest is the small cavity in the eye, corresponding to a reversed cornea. This depression catches a shadow which gives considerable expression to the eye.

Principles of Modern Psychology

Enabling the Individual to Develop His Good Points to the Best Advantage

IN *Mental Hygiene* for Jan., 1921, Dr. W. A. White presents an important analysis of the Principles of Modern Psychology with especial reference to "The Behavioristic Attitude." Behaviorism, says Dr. White, looks upon what a man does in contrast to what he thinks and feels—that is, upon his conduct—as being the most important expression of his psychology. In other words, his actions are taken as the only authoritative expression of what he is. Thinking and feeling have significance only so far as they are preparatory for and lead to action. The man who thinks and feels, but does not translate his ideas and emotions into action, is hamstrung by doubt. Failure to act in the ordinary sense is, however, itself action. A body comes to rest only because the forces that act upon it are for the time being in equilibrium.

The outstanding fact is that organisms are constructed on a pattern which has action for its purpose. Life itself has been defined as consisting of that constant back-and-forth flow of energy which constitutes the relation of the organism to its environment. Every change in the environment must be met by an adjustment on the part of the organism, and that adjustment involves action, or expressed in physiological terms, reaction. The adjustment effected brings the organism into functional contact with the environment at more points than before and therefore necessitates further reactions of adjustment, the growing number and complexity of which constitute development in the individual and evolution in the race. This fact alone justifies the emphasis of the behaviorists on conduct.

The great change that has come over psychology in recent days is, then, that it has been humanized. In the days when psychology was metaphysical and academic, it was a subject for meditation in one's study; it had, strangely, almost no touch with the living, pulsing problem of human life. It was more interested in discussions of the nature of the soul than in such questions as why men failed in life. Failure of any kind was hardly recognized as a biological problem of adjustment, and so its real psychological significance failed of appreciation. Now, however, the whole tendency has changed, and it is just such problems as the criminal, the insane, the defective, the vagabond, the prostitute, the neurotic, and all sorts of minor disabilities that interest it most.

To come to the question of the Why of some of these failures is to revert to the fundamental behavioristic conception of man as a complex of action systems or action patterns.

One of the very obvious reasons for faillure lies in the fact that the machinery which a man has at his command, *i.e.*, his bodily machinery, his vital organs in all their complexities and intricate interrelations, is inadequate to the carrying out of a socially acceptable life plan.

An astonishingly large percentage of the unfit, the social outcasts, are seriously handicapped by bodily disease, while approximately 50 per cent of all classes are as seriously impaired by obvious or comparatively easily discoverable mental disease.

The two classes are, however, not so widely separate as this statement would lead one to believe. We have passed out of that stage of evolution in which success was solely a matter of blood and brawn, strength to kill or fleetness to escape, and are living in a period in which the struggle for survival, for success, is a contest of wits, a matter of brains. Therefore, we may look upon failures of adaptation as predominantly failures at the psychological level.

The organism is something more than a collection of organs; it is a collection of organs that are related in such a way that they may all, like the several parts of a complicated machine, be brought into the service of a common purpose, and the head end is the device from which emanates the directing force for such integrated activities.

Body and mind are, then, not separate; they have grown up and evolved together as part and parcel of the same thing, the one consisting of the parts, the other of the integrated relation of the parts.

Behavior, then, is seen to be of necessity the final expression in action of the whole, so to have the importance that the behaviorists attach to it. Defects in the individual—whether they be of mental or of bodily origin, whether they depend upon mind in the first instance or are traceable and dependent upon some defect of an organ, such as blindness—ultimately find their expression in conduct.

Failures are not, despite the fact that they often appear to be, solely individual affairs, but defects at the level of ad-

justment between the individual and his fellows, or at the psycho-social level. It is because this is so that the large class of unfit are social problems.

Now society has always, heretofore, been primarily and, for that matter, solely interested in the conduct of its members, in their acts, and whenever it has found some one doing things that tended to its disadvantage, it has sought to put a stop to such acts with very little thought of the actor, the doer of the act. It is as if you should consult a physician for a pain in your leg and he should at once relieve you of the offending member by amputation.

With increased knowledge, there has come a realization that there are other ways to tackle the problem that are more rational and bid fair to attain better results. The tendency in dealing with the delinquent, defective and delinquent classes today is a tendency toward a greater individualization, a tendency to deal, in other words, with the actor rather than with the act.

At this point Dr. White parts company with the extreme behaviorists who would discredit the internal evidence entirely. For the behaviorist what a person thinks and feels is of no significance, and to society what a person thinks and feels matters not at all. It is only what one does that counts. But psychologically, from the standpoint of the organism as a complex of action systems, thinking and feeling are but acts *in statu nascendi.* Many acts never get beyond the thinking and feeling stage, are never translated into conduct, and in connection with every one that is, there are certain other, counter assertions, of opposing tendency, which, while they do not gain frank expression, are at least able to modify to some extent those that do.

This arrangement by which conduct is the result of choice between opposing tendencies, each of which with varying force tries to avail itself of the machinery of expression, is *the plan upon which the organism is built up.* This is a figurative way of putting the case for what the psychoanalyst calls the *wish.* All of these tendencies within the psyche which are struggling for expression are wishes in the sense of this school, and it is only by knowing what they are and their relative strength that a dynamic plot, so to speak, can be made of the personality.

The wish to conform, to be well thought of by one's fellows, is practically always dominant, but behind each such wish there is another, antisocial, infantile in tendency, that also seeks expression. The first is almost sure to succeed, but the degree of its success is measured by the strength of the second.

For example, the soldier who was afraid to go forward was also afraid not to because of the discredit his failure would bring in the opinion of his associates. For the same reason he was afraid to run away. The dread of loss of social esteem was often sufficient to over-balance a fear that was not strong enough to be controlling, and he went forward. But for some the fear of going forward was so great that it was impossible to do so. Equally, death faced them in the form of a firing squad if they ran. The solution was, say, a neurotic paralysis of the legs which so crippled them that they could not walk, much less go forward or run away. The solution of the *impasse* was illness, but the illness itself was a concession to the social demands. Illness is respectable, cowardice is not.

There are now two approaches in helping to better inadequate adjustments. One may try to change the individual, as already indicated, or one may try to change the circumstances. The former particularly requires a certain attitude of mind in oneself which is essential to success. It is the attitude of the scientist. It is impersonal in the sense, that it is not fraught with sentimentalism, which is dangerous, or with a sympathy that may be binding. It requires an understanding based on knowledge and an unqualified desire to bring to pass a better state of affairs, untinctured by self-seeking motives.

As showing the importance of this state of mind, it is known that the anti-social wishes that find expression in conduct are unconscious to their host. Modern psychology has demonstrated that the larger part of our mental life, that portion from which comes all the motive power for conduct, lies beneath the threshold of what we ordinarily call our conscious selves. This is the region in which all that complex battle of motives occurs which ultimately surges to the surface and finds expression in actions of which we are aware. Therefore, blame is an unscientific and useless attitude with which to approach an attempt to effect any change in the results.

Human nature has been in process of evolution a very long time. The period covered by history represents only a very short part of the time during which the process has been going forward. The differences between people are very much less than their resemblances, and those differences are in degrees of equipment, which make some a little better able than others to handle their problems. All have at their best something worth while, a percentage, be it ever so small, of efficiency, if only the circumstances are not made too hard. For these problems of society modern psychology is to find adjustment which will most nearly enable people develop their good points to the uttermost, which will help them to be of the maximum social value within their limitations.

This is the method of attempting to make available the energies of the individual to the best advantage. It is quite different from hanging a man because he has stolen two shillings, cutting off his leg because he has a pain in it, or discarding a broken part of a machine and putting nothing in its place. It deals with the human machine and with the social machine as with machines elsewhere—as means of utilizing energy.

THE DIET OF CAPTIVE APES

CAPTIVE apes have an unfortunate reputation of being filthy in their habits and, in particular, of spending much of their time in the Neapolitan practise of ridding themselves and each other of vermin. A well-known German naturalist, Dr. Th. Zell, thinks this reputation unjust and that the seeming search for vermin in the case of captive apes is really a search for crusts of salt, a habit to which they are driven by a lack of this element in their diet. Writing in a recent number of *Ueber Land und Meer* (Berlin), he says: "More than twenty years ago the old keeper, Huebner, in the Primate house at the Berlin Zoo, told me that his apes were quite free from vermin and that the public had an entirely wrong idea with respect to their supposed mutual search for parasitic insects. In his opinion the apes were really seeking dried cakes of sweat because of their salty taste. . . . In the newest edition of Brehm's Natural History, Professor Heck, the Director of the Zoo, expresses the same opinion. . . .

"In support of his view, Professor Heck remarks that captive apes seldom suffer from vermin. Wild apes, however, are certainly afflicted with parasites, with which African travelers often assure us they fairly swarm. Alfred Brehm, who lived in Africa for a long time, tells us that the leader of a troop of apes, who is always the strongest individual among them, is carefully deloused by the females under his command, and that this is one of their ways of pleasing and catering to him . . . and that he receives these courtesies with all the dignity of a Pasha served by his favorite slave."

With regard to tame animals the dirty and disgusting habits with respect to their food displayed in some instances, is held by Dr. Zell to be merely the attempt of an improperly nourished animal to supply some serious lack in its diet, and in behalf of this view he cites the following instances:

"Swine are semi-beasts of prey for whom a certain amount of flesh in their food is a necessity. In spite of this fact we confine our domestic swine to a vegetable diet alone and then express great wonder that a sow should be guilty of devouring her own litter. We are accustomed to provide our cows, goats and sheep with lumps of rock salt which they may lick at pleasure to satisfy the need of this mineral. . . . Our captive apes should have similar provision in their cages."

Chemical War on Disease*

Action of Certain Chemicals on Toxins That Are Responsible for Infectious Diseases

By Dr. H. Schwarz

DURING the past quarter century the medical sciences have made astonishing progress in all branches, but particularly in the field of serotherapy. This science constitutes, in actuality, one of the most powerful weapons available in the battle against a great number of infectious diseases.

SEROTHERAPY AND CHEMICAL MEDICAMENTS

However, many diseases are caused by protozoic infections, and such are very difficult to combat by means of serums. Sometimes this sort of treatment is altogether inapplicable and in these cases chemical methods of attacking the malady have proved to be very successful.

This marked the birth of a new branch of medical science, which has for its object the study of the action of certain chemicals on the toxins that are responsible for infectious diseases. It is also concerned with the destruction of the germs of disease by the aid of chemical substances within the body of the animal (the human body). Chemico-therapy is the name given to this new science, whose aim may be epitomized as "internal disinfection" of the human organism. Its task is to find chemical substances which are able to combine with the pathogenic parasites in the blood in such a manner that the latter are destroyed or rendered at least incapable of being propagated any further without these chemicals injuring in any way the organism itself.

PARASITOLOGY

Those substances which act on parasites are known as "parasito-tropes." Parasito-tropy takes place each time that the parasites are destroyed or isolated by the chemical molecules. However, the substances that are "parasito-tropic" in their action are also "organotropic," that is, they possess a chemical affinity not only for the parasites, but equally as well for certain vital organs or cellular tissues in the human body.

Hence, from the medical standpoint it is very essential to know both the organotropic and the parasito-tropic properties of a substance before it can be administered internally. The two must bear a definite relation to each other in obedience to a special parasitological law. The parasito-tropic properties must be stronger than the organotropic so that while the chemical destroys or neutralizes the germ it does not hurt the organism itself too severely.

THE THERAPEUTIC COEFFICIENT

It has been possible to foretell the action of a chemical medicament by determining its therapeutic coefficient. This is a mathematical quotient obtained by dividing the "curative dose" (C) by the "tolerated dose" (T).

The first thing to be done is to determine how much of the substance the organism can stand. Then it is found by tests just what quantity of the chemical will kill the parasite. From a chemico-therapeutic point of view it is evident that the most useful medicament will be the one whose "tolerated dose" is large in proportion to the "curative dose." In other words, the therapeutic coefficient should be as small as possible.

THE SALVARSAN COEFFICIENT

A very good example in the use of this coefficient is found in the arsenical medicament, salvarsan (the world-famous anti-syphilitic drug). The ratio $\frac{C}{T}$ varies according to the number of times a dose of the medicine is given. For the first time it is 300:800 or $\frac{1}{2.7}$ but as the human organism becomes accustomed to the action of the drug, the ratio diminishes, becoming 300:1000 or $\frac{1}{3.3}$ for the second dose and 300:1500 or $\frac{1}{5.0}$ for the third dose.[1] This explains why the first dose of salvarsan is always considered to be the most dangerous in its action on the system and why it is best to administer only a small amount of the drug at the outset.

ACTION "IN VITRO" AND "IN VIVO"

It has been observed that a great many substances are capable of destroying parasites when the experiment is made in the laboratory, in the test tube (in vitro), but are absolutely devoid of action on them in the human or animal body (in vivo). The parasito-tropic properties of the substance are then evidently much weaker than the organotropic properties. When the drug is administered internally it acts on the tissues and the organs far more than on the parasite. On the contrary, there are certain medicaments which are entirely inefficient in vitro but which give very excellent results in vivo.

Hence, there is no direct concordance between the reaction that takes place in the experimental apparatus and that in the body of the animal. Furthermore, neither is there any agreement between what happens in the animal body and in the human organism. Ehrlich has demonstrated that even when a substance has been tested out as carefully as possible and all the conditions have been chosen properly so as to yield the most accurate results, nevertheless it is not always possible to apply these results with safety in experimentation in the human body.

The importance of the conceptions of organotropy and parasito-tropy is paramount in the study of *immunity*. The experimental proof of the existence of chemical affinity between the parasitic cells and certain chemical substances, and other facts of like nature, derived from the results of actual experimentation have formed the basis of the "theory of lateral bonds."

THE THEORY OF LATERAL BOND

This theory has been the subject of numerous attacks, but it has proven to be of great service in explaining many facts which would otherwise be very difficult to understand. The fundamental principle, on which the theory is based, is that the living cell differs from lifeless matter in that it is able to choose from all the substances which may be found within the sphere of its action, those which are suitable to it and which can be useful to it. It is indifferent to all others.

THE CHEMICAL CONCEPTION OF THE THEORY

We are confronted here with the fundamental property of protoplasm, which we cannot explain. The best that we can do is to express what happens in chemical terms, which helps us to follow through the course of the phenomena, related thereto, more easily. We say that there must exist a "chemical affinity" between certain chemical groups in the living cell and certain chemical groups in the substance that is absorbed. Based on this assumption, it follows that each time that a cell absorbs or rejects a nutritive substance, the phenomenon of attraction or repulsion takes place between the various chemical groups. Hence, the cell changes its outward appearance in-

*Translated for the *Scientific American Monthly* from *Chemie et Industrie*, Jan., 1921, pp. 18-26.

[1]For "trixidine" (Sb_2O_3), the coefficient is 1:100—a very effective drug.

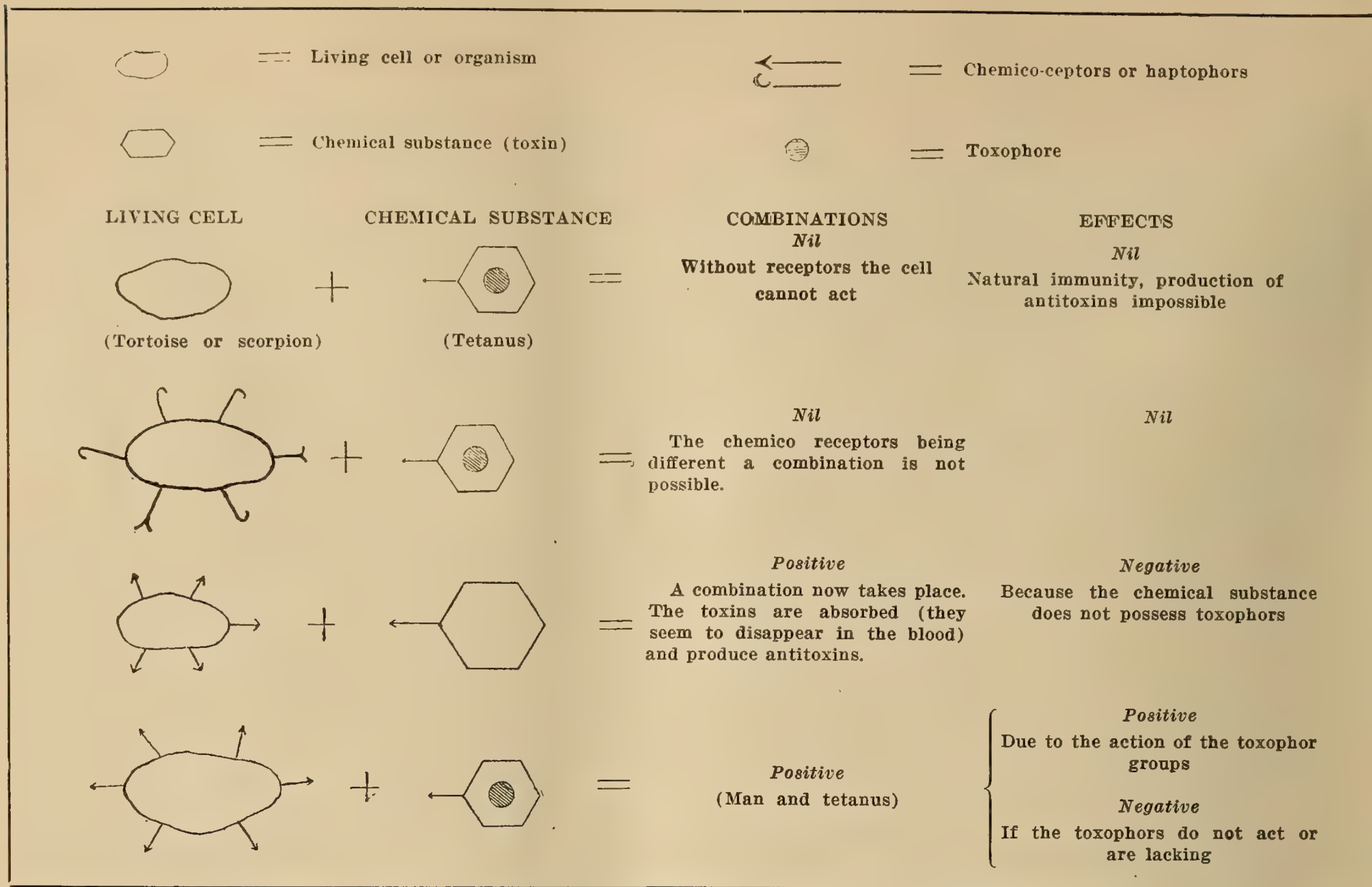


FIG. 1. MECHANISM OF THE PARASITOLOGICAL PROCESS

cessantly, which can be observed in the variation in the atomic concatenations. But in spite of the numerous modifications that take place in the cell no profound transformation occurs. It remains essentially the same until it dies.

THE STRUCTURE AND THE PLAY OF FORCES IN THE LIVING CELL

It is supposed that the cell contains in its center a vital nucleus, immutable in its substance, and responsible for the maintenance of the individuality of the cell. The central nucleus is conceived as being surrounded externally by many atomic bonds, which are very mobile, variable, and ever ready to detach themselves and to reëstablish themselves once more in combination with the nucleus. These bonds are the servants of the nucleus. Hence, everything that comes within the influence of the sphere of action of the cell, must first come in contact with these lateral bonds, or "receptors" as they were called by Ehrlich.

If it is assumed that every time that any substance whatsoever combines with the living cell, the association takes place because of a chemical combination, "effected by the lateral bonds," it follows that the living cell will give admittance to those substances only, which possess an affinity with its lateral bonds. This means that these bodies contain themselves groups, which are able to form chemical combinations with the lateral bonds of the cell. Whenever a substance is placed in juxtaposition to the cell, or whenever it penetrates it, then we attribute that phenomenon to the existence of atomic groups that combine with each other, and of which some belong to the lateral bonds of the cell and others to the substance in question. Ehrlich gave the name of "chemico-receptors" to the chemical groups, contained in the lateral bonds of the cell, and "haptophors" to the chemical groups in the chemical substance.

In order to avoid an erroneous interpretation of this theory it is to be remembered that it is not concerned with the absorption of nutritive solutions, such as sugar in solution, nor with toxic substances, such as arsenic, etc., for these substances are absorbed, as is known, not in accordance with the laws of diffusion, solubility, etc. The doctrine in question is concerned only with particularly complicated substances, which are not very soluble in water, as for example, albumen, the toxins, the ferments, etc.

A distinction may be made between two cases. In the first case a chemical substance is absorbed by the cell, provided the substance possess "haptophores" which are able to combine with the "receptors" of the living cell. In the other case, the substance is not absorbed. However, it is not enough to state that the substance is absorbed by the cell; it is necessary to explain in addition the *action of the substance on the cell.*

It is assumed that the substances, provided with "haptophores," contain characteristic atomic groups, which exercise a decisive influence on the nature of the reaction. This explanation is borrowed from the theory of dyestuffs. Just as there are certain groups which cause the dyestuff to fix itself on the fabrics and others which are responsible for the tone of the color itself, so in this case the influence of the active groups is not felt until the combination with the living cell has been accomplished. When the question is concerned with a toxic group ("toxophor"), then the cell is either destroyed or isolated. If there is no affinity between the "receptors and the haptophors," then the toxins have no action on the cell. (See Fig. 1.)

The mechanism of the parasitological process as depicted in Fig. 1 enables one to distinguish between the different degrees of sensitivity exhibited by animals toward various kinds of toxic substances. When an organism (as for example the tortoise or the scorpion) does not possess the necessary "receptors" to react with certain toxins (for example the tetanus toxin), then the latter has no effect on it. (This is shown in line 4 in the figure.) And likewise, neither do the cells of this organism attack the toxin. Hence, the toxin is absolutely neutral in the physiological sense. This explains why the tortoise or the scorpion is not affected by the tetanus virus and why this can circulate in the blood of the animal for many

days without being changed in any way. On the contrary, when the virus is injected into the human organism or in other animals that are sensitive to it, it begins to disappear at once, indicating that the cells of the body are attacking and destroying it. When as in the human body the "receptors" are numerous and localized in vital organs, the poisoning effect of the virus is intensified to a very marked degree.

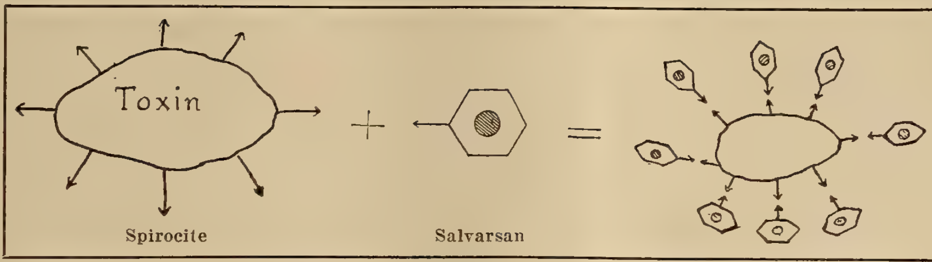


FIG. 2. DEATH OF THE CELL (SPIROCITE) BY COMPLETE POISONING
Combined effect of the toxophors and the liaison

NATURAL IMMUNITY

The definition of natural immunity is very readily developed from these facts. The blood cells of the tortoise or the scorpion not having the proper "receptors" do not combine with the tetanus toxin; hence, they are from their very nature immune to the disease. Of course immunity may be only partial. A regular scale of immunity to tetanus has been prepared. The horse is least immune, then come the mouse, the rabbit, the pigeon, the chicken and finally, the cold-blooded animals, the alligator and the tortoise, which are absolutely immune.

THE POSITION OF THE "RECEPTORS"

It has been developed that not only the number, but also the position of the "receptors" are determinant in establishing the immunity of an organism to certain parasites. The cells of the central nervous system are the only ones sensitive to the action of tetanus virus. Such cells are capable of transmitting the action of the virus and when this takes place in such a manner that the organ, menaced by the virus, is not entirely in danger, then the virus can be isolated without its action's entailing the death of the organism. The animal then also possesses "natural immunity."

THE PRODUCTION OF ANTITOXINS

A cell whose "receptors" are occupied by disease viri lives in a troubled state of existence. The "lateral bonds" of the cell possess a certain physiological function and that is suspended, due to the invasion of the cell by the pathogenic parasites. What does the cell do? It follows the natural physiological law in attempting to remedy the situation. All that it has the power to do is to replace the lateral bonds, occupied by the disease virus, by a new growth of the same.

It is a principle in physiology that, when a cell acts to compensate itself for the loss of something that it lacks, the compensatory process does not stop at mere replacement, but proceeds to the state of hyper-compensation. The cell secretes "lateral bonds" continuously, which are endowed with the same structural characteristics as those which have been destroyed. This process goes on until the cell cannot carry the large number of "lateral bonds" itself and must cast them loose. Then these "receptors" set free, circulate through the blood stream.

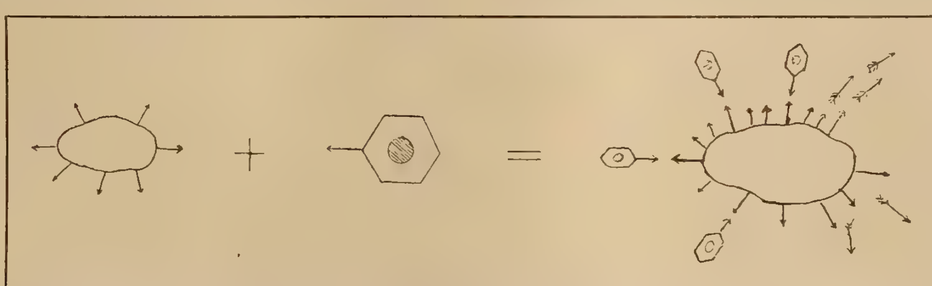


FIG. 3. THE FORMATION OF ANTITOXINS
A result of insufficient poisoning action and a consequence of the biological hyper-compensation

These organic particles contain albuminous substances characteristic to the organism in which they exist and hence are not subject to attack by the destructive forces of this organism. They remain intact for a long time. But, they possess a strong affinity for the virus which had occupied the cell by which they were produced. Hence, whenever they come in contact with the toxin a chemical reaction takes place and the toxin is destroyed just as happens in the case of the living cell. By virtue of their action on the toxins they are said to behave like "antitoxins." (The process of the production of these anti-bodies is shown graphically in the diagram Fig. 3, the detached "receptors" being represented by arrows.

THE ANTI-TOXINS

Hence, the anti-toxins are nothing more than the "chemico-receptors" which have become separated from a cell because of a physiological deficiency therein which gives rise to the phenomenon of hyper-compensation. It is impossible for a cell to produce anti-bodies when deprived of "receptors."

An analogy between the action of the anti-toxins and that of a lightning conductor is very striking. While the anti-toxin, that is the chemico-receptor which is endowed with a strong affinity for the "haptophore" of the disease virus is within the cell itself then it attracts the toxin to the cell. On the other hand, when it is without the cell, then it protects the latter because of its strong affinity for the toxin, whereby it forms with it an inactive combination and prevents it from exercising its death-dealing properties. The lightning rod attracts the lightning to the structure but by affording an easier path of escape protects it from destruction. A graphical demonstration of the process is indicated in Fig. 4.

THE ACTION OF ANTI-TOXINS

A useful application of the theory of lateral bonds is in the explanation of the effect produced by tetanus virus on the hen. To kill the fowl large amounts of the venom must be injected subcutaneously, but a comparatively small quantity will result in death when injected into the cranial cavity. It is evident that the cells in the nervous system are very sensitive to the poison. But there are also many cells in the subcutaneous tissue which are able to combine with the virus and to such an extent that the poison does not reach the central nervous system. That is why the fatal cranial dose does not kill the fowl when injected under the skin, but results in the formation of anti-toxins.

SENSITIVITY TO DISEASE AND PRODUCTION OF ANTI-TOXINS

It is not necessary that an animal be sensitive to a disease for it to produce anti-toxins which act against the disease virus. The reason for this lies in the fact that cells furnished with receptors may combine with the haptophors of the venom and produce anti-bodies but may not suffer any toxological effects therefrom. There is a very marked difference

between the function of the cell resulting in a "state of combination" and the "effect produced" in it.

Hence, the alligator which is absolutely unaffected by tetanus nevertheless produces large quantities of tetanus anti-toxin (*Compare diphtheria and the horse.* Trans.) On the other hand, the scorpion which is equally resistant to tetanus does not produce a trace of anti-toxin.

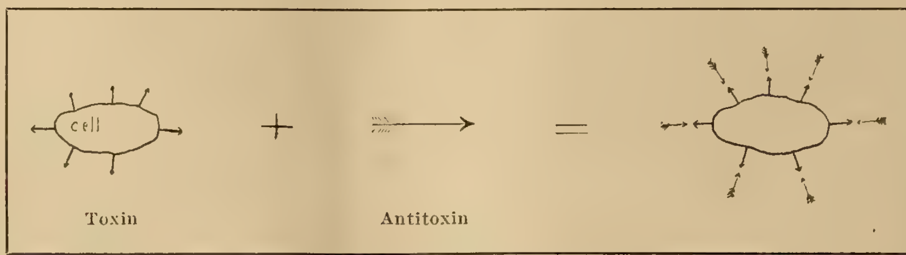


FIG. 4. NEUTRALIZATION OF THE TOXIN

The toxin is not poisoned by the antitoxin, as by chemical substances. It is only rendered impotent by the simple act of neutralizing or occupying its receptors

THE EFFECT OF TEMPERATURE ON IMMUNITY

Besides immunity due to the absence of the necessary groups in the cells of the organism to effect a combination with the disease venom, there is the immunity due to temperature which is of lesser importance. The only known case is that of the frog in its sensitivity to tetanus. The frog does not react to an injection of tetanus virus unless the temperature reaches 25 deg. cent. Then it dies. The explanation of this is that the toxophor group does not act without the aid of heat, although the toxin is already fixed in the cold.

While certain animals possess "natural immunity," that is, are insensitive to certain diseases from their very nature, others—in which category man is included—must have created in them an "antitoxinal immunity," that is, the capability to resist the disease by the formation of anti-toxins. Parasites (such as the tetanus bacillus, the diphtheria bacillus, etc.) are dangerous only when they have real toxic bodies in their organism. As soon as they have been deprived of these formidable weapons they become inoffensive parasites incapable of being propagated and which soon die. It is well known that very often there exists in the human body the parasites of disease—as for example the presence of the diphtheria germ in the throat—which, however, cannot cause any illness.

CHEMICO-THERAPY

As has been explained, chemico-therapy is the science which is concerned with treatment of disease by means of chemicals. The development of chemical medicaments which, when introduced into the system, will destroy the parasite without injuring the tissues of the bodies is based on the principles developed in the synthesis of dyestuffs. The question there is to produce certain changes in the color by the introduction of various groups in the compound. In chemico-therapy we are concerned with the variation in the physiological effect of a substance by the change in its composition through the substitution of one group for another. Ehrlich used his experience with coloring matters in his biological researches. He made tests on animals with more than two hundred dyestuffs. After they were injected into the blood of the animal he studied very minutely their distribution throughout the organism. Some substances appeared principally in the nervous system, others were fixed by the fatty tissues, etc. The *tropy* of a substance was thus determined as its aptitude to fix itself in a particular part of the organism. Substances which act on the brain are called neuro-tropic; those which act on parasites parasito-tropic.

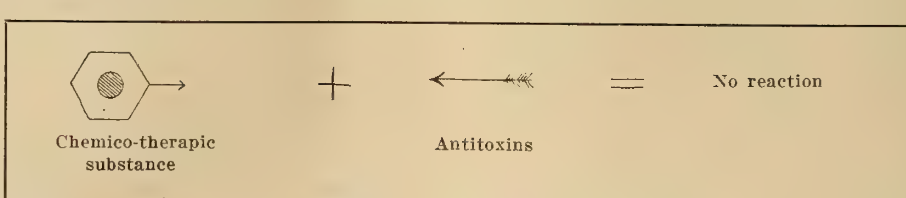


FIG. 5. NO REACTION

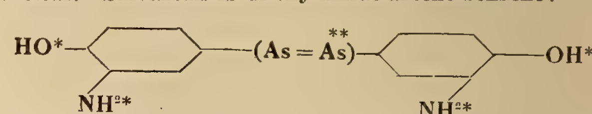
The antitoxins prefer the receptors of the cell to the haptophors of the chemical products

It was known for a long time that arsenic had a very strong action on the parasite which causes the dread disease syphilis. The chemical and physiological properties of the organic compounds containing arsenic were not understood very well. It was thought at first that the compound, atoxyl, would give very good results. This substance was considered to be a meta-arsenic anilide, possessing the formula $C_6H_5NH.AsO_2$. However, when it was injected into the human system, it produced blindness, although it killed the disease germ. The next step was to obtain another compound belonging to the same class as atoxyl, but not possessing its violent organo-tropic properties. Granting the above constitution to the compound, there was no hope of being able to modify the structure of it in order to obtain the desired amelioration of its toxic properties.

However, when this substance was examined more carefully, it was found that the original structure, assigned to it, was not correct. A compound was developed which was called theatoxyl of a sodium salt of para-amino-phenyl-arsenic acid. The formula of this substance is p — $C_6H_4NH_2$. AsO(OH).ONa. Here we have a substance which admits of many substitutions and additions. In the first place it is possible to change the amino (NH_2) group so as to get a series of many derivatives of the arsenic acid. Then again, the compound can be diazotized and numerous azo coloring matters synthesized therefrom. Other transformations can be made likewise, and in these ways a large number of compounds can be obtained, whose toxic properties can be regulated at will.

Starting with the original substance, atoxyl, and working various changes therein, Ehrlich finally succeeded in finding a compound which possessed the proper therapeutic coefficient and which gave good results in the treatment of syphilis.

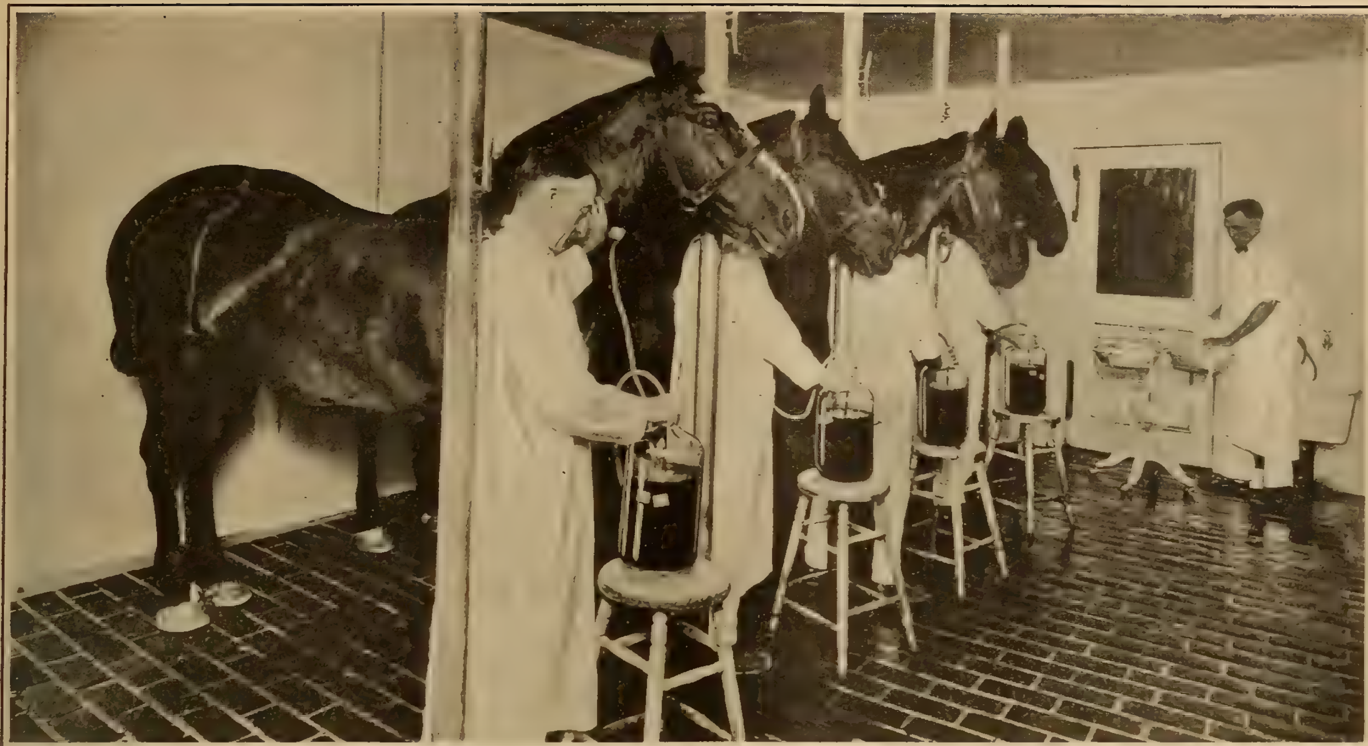
The study of the action of the arsenical compound on the syphilitic parasite, known as the spirochetic cell, revealed the fact that the cell possessed a number of different receptors. Among the most important of these were the oxamide and halogen receptors. The action of salvarsan on the parasite is now clear. Salvarsan is di-oxy-amide-arseno-benzene:



The haptophor groups OH and NH_2 combine with the receptors of the spirochetic cell and thereby prevent the cell from combining with the vital cellular substances of the human body. The toxophor group — As:As — destroys the cell. The presence of the NH_2 group close to the OH group enhances the fixative action of the OH group.

The importance of this comparatively new science of chemico-therapy is vital. The chemist now knows what is required from the chemical compound that he is developing for medical use. The future of the science is very promising.

*represents the haptophor group
**represents the toxophor group



BLEEDING HORSES FOR ANTI-PNEUMONIA AND ANTI-MENINGITIS SERUM
The operation is painless and the animals suffer no discomfort nor permanent injury

Vaccines and Serums

Modern Methods of Preparing Medicaments for Killing Microbes

By Donovan McClure

THE ancients had a saying, "Take a hair of the dog to cure its bite," a rough and ready sort of popular proverb to indicate the vague idea that in some cases like cures like or as the Latins had it "*Similia similibus curantur.*" But it was not until Jenner discovered that the dread scourge of smallpox might be mitigated by inoculation with the virus of cow pox, a similar disease in a bovine host, that the idea began to really emerge from the shades of supersition which marked its early application.

The next great step was Pasteur's discovery that disease may be caused by bacteria or microbes. Later, Metchnikoff, the great Russian physiologist, discovered that those large white blood corpuscles which move hither and thither among their smaller cousins, the red blood corpuscles, in the plasma of the blood, have the remarkable property of being able to destroy such disease breeding bacteria as may make their way into the swift red current of life. Because of this power of absorbing and digesting pathogenic micro-organisms the leucocytes or white blood corpuscles are also known as phagocytes, *i.e.*, devouring cells. Some months ago the writer had the unusual privilege of being a guest at a demonstration of this subject given at the Rockefeller Institute in this city before an audience of physicians and nurses showing how this is accomplished. The lecturer was a brilliant young French surgeon attached to the Institute at that time and his lecture was accompanied by some very remarkable moving pictures showing one of these big soldier cells in hot pursuit of an invader. The audience was thrilled with excitement as the avenger swiftly and surely drew in upon the offending microbe, surrounded and demolished him and the volatile French physician shouted gaily "Atta boy, atta boy!" as the policeman drew near the criminal.

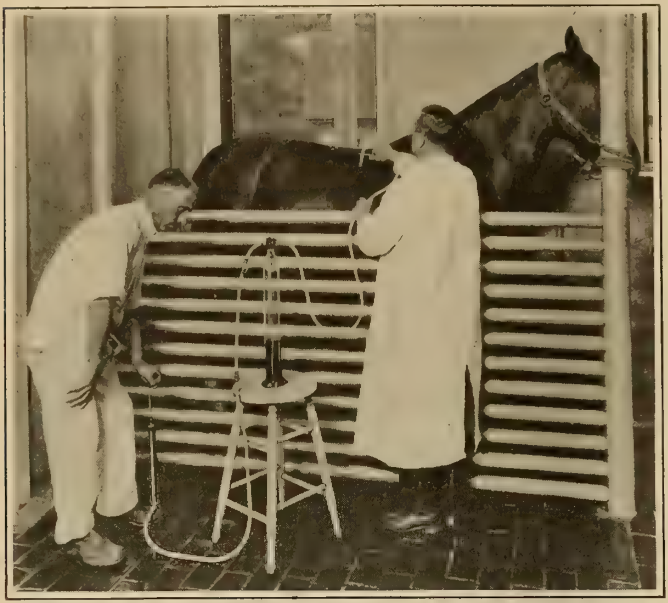
The next important step in advance was made by Sir Almoth E. Wright, the famous London physician, who did such good service in the war. In studying this phenomenon he found that this germ killing power of leucocytes is much greater when they are suspended in a blood serum obtained from animals which have been previously immunized than when they are floating in normal blood serum. He also found that the phagocytic power of the white blood corpuscles largely depends upon the presence in the blood serum of certain substances which act upon the invading bacteria in such a manner as to make them more readily susceptible to attack; in other words these substances, which were termed *opsonins* by Dr. Wright, are said to sensitize the enemy organism. Further study of the matter led Dr. Wright to conclude that during the process by which a living body obtains immunity from a given disease, these opsonins are greatly increased by the operation of natural forces, and he next discovered that they may be artificially increased by the injection of bacterial vaccines.

BACTERIAL VACCINES

Bacterial vaccines consist of dead disease germs suspended in what is known as a physiological salt solution, *i.e.*, a very weak solution of sodium chloride in water. This fluid is sterilized and is very carefully standardized by counting the number of bacteria, so that each cubic centimeter shall contain a definite number of them.

Therapeutic Action.—The power of bacterial vaccines to cure a disease or ameliorate its progress is due to the fact that they exert a stimulating action upon the cells of the patient's own body, causing them to increase their natural efforts of producing so-called anti-bodies. The word anti-body is analogous, roughly speaking, to the more familiar term of antidote, and the anti-bodies include not only opsonins, but agglutinins, precipitins, bacterial lysins, and other substances antagonistic

to bacteria. This heightened production of such protective substances leads to a state known as *active immunity*, and this well guarded condition often lasts for many years. The best known instance of such protection is smallpox vaccination.



METHOD OF INJECTING HORSES FOR THE PRODUCTION OF DIPHTHERIA AND TETANUS ANTITOXINS

The animal receives an injection every five days for from three to six months before there is any yield of antitoxin

Preparation.—Bacterial vaccines are prepared from cultures of pathogenic bacteria which have been grown upon suitable media under the most favorable conditions. *Several strains of the respective organisms are used* in the best laboratories for it has been demonstrated clinically as well as in the laboratory that different cultures of the same organism may vary widely in biochemic properties, and that most vaccines should be polyvalent in order to possess the greatest efficiency. *Polyvalent* means that the suspension contains several cultures of the same species of bacteria—that is, *several "strains" of the organism are used*—the cultures being obtained from many different sources of infection in which that species of organism is found. *All of the bacterial vaccines prepared in some antitoxin laboratories are polyvalent*—the single as well as the combined (mixed) vaccines. This statement, however, is not applicable to typhoid vaccine in which only one strain of the typhoid bacillus is used; because this particular strain has proved to be most efficient in the use of typhoid vaccine in the United States Army and in the armies of other countries. *A combined (mixed) vaccine* contains the various species of bacteria generally present in a mixed infection; for example, pneumococcus combined vaccine (mixed) contains the pneumococcus, streptococcus, and staphylococcus.

The bacterial cultures, which are usually grown on some solid medium, are washed off with physiological salt solution and thoroughly shaken to separate the organisms; the bacterial suspension is subjected to a careful count; the organisms are killed by heating the suspension and by the addition, after cooling, of 0.25 per cent trikresol. The suspension is then diluted with sterile physiological salt solution, containing 1.25 per cent trikresol, until each cubic centimeter contains the desired number of bacteria.

Uses.—Bacterial vaccines are used in acute, subacute, and chronic infections.

Since a large majority of diseases are due to mixed infections the combined (mixed) bacterial vaccines have been prepared for treating such cases. These combined (mixed) vaccines contain combinations of those organisms which have been found most frequently associated in producing or aggravating such diseased conditions. Very often, where treatment with a single vaccine produces little or no result, the use of a combined (mixed) vaccine is followed by very striking and positive results.

Method of Administration.—Bacterial vaccines are administered subcutaneously by means of an ordinary hypodermic syringe; the instrument must be properly sterilized, preferably by boiling, or by repeatedly washing it out with 5 per cent phenol solution—the needle must also be cleansed internally and externally by the same means—and the instrument should finally be rinsed out with boiled water.

The injections may be made in the region of the shoulder blade, in the arm at the insertion of the deltoid muscle; in the gluteal region; in the abdominal wall—in short, at any point where there is sufficient subcutaneous tissue, preference being given to the region in which the injection will produce the least pain or discomfort. At the point of injection the skin may be painted with iodine or cleansed with soap and water and mopped with alcohol. Any air contained in the syringe should be expelled before injecting the vaccine. After the operation the site of injection may be protected with a sterile gauze dressing, or may be wiped with a pledget of cotton moistened with alcohol.

The container should be well shaken before using the vaccine in order to suspend any bacteria that may have settled out on standing.

The amount of vaccine required varies according to the age and personal characteristics of the patient; the type, duration, extent, and severity of the infection, and the identity of the organisms. When the general condition of the patient is good, the response to the vaccine is more effective; hence, it may be necessary to administer the vaccine every 24 hours or oftener to an extremely ill person, while every five days may suffice for a convalescent patient.

As a general rule the intervals between the doses in acute

FILLING SYRINGES WITH ANTITOXIN

Every precaution is taken to avoid contamination. Sterile caps and gowns are worn and even the air supplied to the room is washed and purified.

infection vary from one to two days. After the acute symptoms have subsided—as shown by a drop in the temperature and by other signs of improvement—the intervals may vary from two to five days. In subacute and chronic infections the

vaccine should be given every three to seven days, the doses being increased according to the clinical symptoms.

ANTIBACTERIAL SERUMS

Serums vs. Vaccines.—Immune seriums are fluids containing antibodies already formed and are injected into the circulation to supply antibacterial elements without stimulating the body cells to the production of these substances. Hence, in the use of seriums, the antibodies formed by the body cells of the horse or some other animal are supplied to the patient, and a condition of *passive immunity is established* lasting only a few weeks. This is how serums differ from bacterial vaccines: the latter confer active immunity, which in some cases may last for a number of years. Moreover, bacterial vaccines do not contain antibodies; their therapeutic value depends upon their stimulating action on the body cells of the patient, thereby producing various antibodies.

It requires an appreciable amount of time for antibodies to be formed after the bacterial vaccines are infected. Therefore, an immediate immunity does not follow; but, after it is established, the immunity persists for a long period.

It is probable, however, that the formation of immune bodies begins very shortly after the injection is made. On the other hand, the immunity conferred by an antitoxic or an antibacterial serum begins *at once*. If the serum is injected intravenously the entire content of immune bodies is at once available; if the serum is injected subcutaneously or intramuscularly, the immune bodies are available as rapidly as the serum is absorbed. As soon as the serum reaches the circulation the process of elimination is begun and proceeds rapidly; so that within a few days it is hard to discover immune bodies.

Definition.—Serums containing substances which result in the death and destruction of bacteria are called antibacterial serums. Acquired antibacterial immunity depends on the destruction of bacteria before they have had sufficient opportunity to multiply and produce poisons which kill the body cells. Various kinds of antibodies are found in the serums of animals that have acquired antibacterial immunity; the best known of these antibodies are bacteriolysins, opsonins, agglutinins, and precipitins. These prepared antibodies are introduced into the system of the individual by the injection of antibacterial serums which produce a condition of passive immunity.

Immune Serums.—There are two varieties of immune serums: (1) Antitoxic serums and (2) antibacterial serums. The former—represented by diphtheria antitoxin and tetanus antitoxin—neutralize the toxin in the circulation and in the various tissues and body cavities. In diphtheria and tetanus, the bacteria elaborate a poison or toxin which is absorbed into the circulating blood and is carried to the tissue cells, and this toxin must be rendered inert in order to effect a cure of the disease. The antibacterial serums, however, act directly upon the invading organisms and render them inert or destroy them, thereby arresting the disease.

ANTIBACTERIAL VS. ANTITOXIC SERUMS

Immune serums contain antibodies already formed. These antibodies in the antitoxic serums are chiefly antitoxins—substances which neutralize the bacterial poisons or toxins; while in the antibacterial serums the antibodies consist of bacteriolysins, agglutinins, precpiptins, opsonins, and other substances, all of which act directly upon the bacteria and tend to destroy them and their intracellular products.

Uses.—The practical application of specific antibacterial serums, in the treatment of various infections in man, has been used on a large scale. It has been found that by the *early* injection of serum from animals actively immunized to various organisms, the natural resistance of infected individuals can be augmented and the course of the disease materially ameliorated and shortened. Even in desperate cases, injections of large quantities of antibacterial serums have yielded most unexpectedly favorable results; while small doses, in similar cases, have usually been without beneficial action.

Antibacterial serums are preferably used when the disease is severe and the patient's resistance is low. Bacterial vaccines are also used in severe cases; but beneficial effects cannot be expected in as short a time from the use of bacterial vaccines as from antibacterial serums, since the latter contain

REMOVING SMALLPOX VACCINE FROM A VACCINATED CALF
The calves are killed before the vaccine is removed

antibodies already formed; while in the use of bacterial vaccines the body cells of the patient must first be acted upon and stimulated to the production of antibodies. This is necessarily a biologic process consuming a definite period of time, and in some cases it appears to be almost impossible to stimulate the body cells to the production of antibodies.

CONJOINT USE OF VACCINES AND SERUMS

If treatment is begun with the serum immune bodies are at once furnished; but, being contained in a foreign protein they are rapidly eliminated and in a few days only a trace of immune bodies can be detected. In order to establish a permanent immunity a vaccine may be used, and, if injected at about the same time as the serum, will stimulate the body cells of the patient to the production of antibodies which will maintain the immunity; so that the patient will be protected after the antibodies in the injected serum are eliminated.

Therapeutic Value.—The results of antibacterial serums in the treatment of diseases of man have, however, not always been as satisfactory as those obtained with specific antitoxin serums. The chief reasons for failure are:

(1) It is not possible to accumulate, in the serum of immunized animals, antibacterial elements in concentration which is at all comparable to the concentration of antitoxins in antitoxic serums.

(2) It has been impossible to adjust the dosage by any accurate unit of antibacterial elements and the doses which have generally been used have doubtless been too small to produce the desired favorable results.

Preparing Antibacterial Serums.—The usual method of preparing antibacterial serum is to inject gradually increasing doses of a vaccine and an autolysate (auto equals self; lysate equals a product of solution) made from cultures of a given micro-organism into healthy horses. These injections or inoculations of the vaccine and autolysate are made at frequent intervals and many different strains of the bacteria in question are used in preparing them. The vaccines are made in the way described above for preparing bacterial vaccines. To prepare the autolysates the living bacteria are placed in distilled water in an ice box (the temperature being 40 deg. fahr.) and allowed to extract for a week; sodium chloride is then added in the proportion of 9/10 of 1 per cent whereupon the solution is ready to be used for inoculating the horses.

The process of inoculation is contained in the best laboratories for several months. In the H. K. Mulford laboratory which supplied the serums employed by the American forces and to a large extent by their Allies during the war, the treatment is continued until the horses are "hyper humanized" which requires from 3 to 6 months' time. At one time so great was the need of these serums that these laboratories alone had over 1,000 horses undergoing treatment at once; the animals were kept in four groups of stables which were located in three different counties, so as to minimize the danger of loss by fire or other accidents.

SOME MALADIES TREATED BY SERUMS

The diseases to which serum treatment is applicable are various. Best known among these, of course, are smallpox and typhoid fever. Vaccination as a preventive of the former is now practically universal in all civilized countries—parents being required by law to have their children vaccinated at an early age, and the result of this wise ruling has been to practically stamp out the dread disease which formerly not only decimated the population of many countries but inflicted upon those of its victims who escaped death the almost more terrible curse of hideously marred visages. During the war the use of preventive vaccination for typhoid and para-typhoid fever was enormously extended. As a result of this practice our troops were almost entirely free of this disease, which even so recently as the Spanish war slew thousands of our men before they had a chance to set foot in Cuba.

The serum treatment of various eruptive and other skin diseases such as acne, boils, carbuncles, eczema, etc., is comparatively recent, but has already met with a good deal of success.

Diphtheria.—It is not many years ago that diphtheria was regarded as one of the most serious of menaces to children, particularly because of the rapidity of the growth of the bacillus. Thousands of lives have already been saved by the use of diphtheria antitoxin and the best authorities believe that many more cases could be saved by the prompt employment of large doses of this agent. When either children or adults have been exposed to diphtheria, the administration of 1,000 antitoxin units gives a protection which usually lasts 3 or 4 weeks, and is absolute for 10 days. However, the injection should be repeated at the end of two weeks if there is still danger of infection.

When a patient is actually suffering from the disease larger doses must be given, varying from 3,000 to 10,000 units in the early stages or mild cases, but running as high as 50,000 units in severe cases.

TREATING COMMON COLDS AND GRIP WITH SERUM

Recent studies of the almost universal periodic affliction of colds in the head or throat, influenza, etc., have shown that they are caused chiefly by bacteria—generally by several acting at once. The most common of these are the influenza bacillus, the Friedlander bacillus, the pneumococcus, the streptococcus, the staphylococcus, and the micrococcus catarrhalis. When for any reason the natural resistance of the mucous membrane is lowered, which may be the result of sitting in a draught, getting wet feet, going too long without food or sleep, etc., these pathogenic germs which are extremely prevalent hasten to take advantage of the temporary feebleness of their natural enemies and rapidly begin to grow in the mucous secretions which form an excellent medium for their development. These diseases are now frequently treated by a combined vaccine which is specially useful for administering in spring and fall to persons who are subject to frequent colds.

TECHNIQUE OF PREPARING SERUMS

As our pictures show, both the calf and the horse are employed for the production of serums. The calf is made use of, however, only in procuring serums for the milder kinds of maladies. Experiment and experience have shown that the horse is the most suitable of all animals for this purpose. To begin with it has a greater power of tolerance to disease germs, so that larger quantities can be administered and correspondingly it produces antibodies to check their baneful effect with great vigor. Cows and lambs are also occasionally used, but the horse is *par excellence* the source of the serums with which dangerous maladies such as pneumonia, diphtheria, tetanus, hydrophobia, typhoid and para-typhoid fevers are fought. One of man's best friends among the animal kingdom for untold ages, the horse, was never more so than now in spite of the rapidity with which he is being replaced as an agent of traffic by mechanical means.

Let us say to begin with that there is absolutely no cruelty and comparatively little pain involved in the procuring of the serum. Young, strong, healthy horses are employed and they are attended with the greatest care. When it is judged that the repeated doses of the given vaccine injected have raised the resisting power of the blood to a sufficiently high point, tests are made upon small animals, such as rabbits or guinea pigs. As we have said above the time required to produce a serum rich in antibodies, varies (partly according to the age of the horse) from 3 to 6 months.

When the appointed time has come for the animals to sacrifice not their own lives, but from 1 to 2 quarts of blood for the purpose of saving life, each animal is led out by a white robed attendant, as shown in our picture, carefully garbed so that all the conditions may be as safe as possible. The picture calls to mind a row of priests of ancient days ready to sacrifice the steeds of some great chieftain in order that their spirits might accompany him to the happy hunting grounds of the world

beyond. Our modern doctors are no less priests in their service to humanity, but the horse who sheds his blood at their merciful hands remains uninjured and soon recuperates.

The animals must, of course, be tied to prevent struggling, after which the blood is drawn directly from the jugular vein, the utmost care being taken that the operation shall be performed under aseptic conditions.

Technique of Preparation.—The first step is the removal of the blood corpuscles from the plasma. This reduces the amount to not more than one-half. From this there must be removed various substances such as water, mineral salts, etc. This is accomplished by filtering through charcoal in the presence of a weak oxidizing agent. The water is taken out not by heat but by chemical means, *i.e.*, by a drying agent such as lime. When the process is complete it is usually the case that only a few ounces, 4 or 5, of the precious antibodies remain from the original quart of blood.

Standardization.—The next step is standardization, *i.e.*, the determination of the exact therapeutic activity and antibody content of the serum. The method varies somewhat in different laboratories. In brief, we may say standardization includes the estimation of the opsonic index, the complement fixation test and similar immune serum tests. The serum is also subjected to very rigid bacteriological and physiological tests to make sure that it is absolutely sterile. When the finished product is found to meet the required standard, it is at once divided into small doses, usually about 15 minims each, and confined in vials known to the trade as ampoules. They are then placed in an ordinary ice box where they are kept until ready for use. Under no circumstances, however, are they kept for more than a year.

SERUMS FOR ANIMALS

Not only human beings but animals themselves profit by serums as a protection from disease. In the last few years these have been extensively used among farmers and breeders to check the spread of various pests among animals.

Rabies.—Perhaps a typical example may be found in rabies. The earliest reference to this disease was made by Aristotle in the fourth century B.C. While all warm-blooded animals are subject to this terrible acute disease, which was not long ago thought inevitably and rapidly fatal, it is the dog, another of man's best friends, which is most frequently infected and which is usually responsible for the transmission of the disease to human beings or to other domestic animals. The United States is said to have more cases of rabies than any other nation in the world except Italy. In 1912, there were more than 4,000 cases in this country. It is worth noting that there has not been a single case in England since 1902, when the muzzling law went into effect, while Australia has never had a case because of its admirable quarantine laws for animals. The virus is transmitted from an infected animal to a sound one by the saliva of the former, hence it is usually the effect of a bite. The period of incubation varies from 10 days to 6 months, or even longer, and the bite, which may in fact have been a mere scratch, may be entirely healed before the dreadful symptoms make their appearance. These symptoms are of two clinical types, the *excited* and the *paralytic*. It is very important that early symptoms should be recognized since the bite of a dog may communicate the disease from 3 to 5 days before the animal seems to be seriously affected. At this time the animal may be unusually playful and affectionate, but later there is a striking change in the voice which becomes a hoarse howl followed by irregular barks of lower pitch than normal. The poor "mad dog" becomes restless and irritable and may suddenly leave home wandering off for many miles and coming back utterly changed. He does not fight other dogs but bites them and passes on; then swallowing becomes difficult or impossible and convulsions appear. The animal may die in one of these. Generally, however, paralysis comes first.

The *paralytic* form is even more dangerous to the owner than the excited form described above, since the owner may merely suppose that the dog is suffering from a bone in its throat and be bitten upon endeavoring to remove it. The poor creatures are intensely thirsty and wish to drink but are unable to swallow when the muscles of the throat become paralyzed.

Treatment.—Anti-rabic treatment is useful during the incubation period but not afterward. This treatment consists of the injection of 25 doses of rabies vaccine given daily for 21 successive days.

How Bivalves Feed

Effect of Ions Upon the Movements of Cilia

MANY investigators in recent years have studied the vibratory motions of cilia and the modification produced by one or another form of alternation in the medium which surrounds the animal which bears them. The question is obviously of great importance with respect to those edible bivalves of various sorts, which furnish so large a proportion of our food and which obtain their own food supply from the minute creatures, drawn within their reach by the waving motion of the cilia upon their gills.

The results of some recent investigations in this line have been published by Mr. J. Gray, M.A., a fellow of King's College, Cambridge, which add much to our knowledge of the conditions requisite for the proper functioning of such cilia. The special material chosen for study was the gills of the *Mytilus edulis*, or edible mussel, a well-known commercial shell fish. The main current of water drawn into the gills is caused by the lateral cilia, which are very numerous since each cell of the epithelium bears several cilia. The most characteristic feature of their normal movement is a wave or pulsation which passes up one side of the filament and down on the other. The lateral frontal cilia are used for straining and assist in passing food from the main current on to the frontal cilia, which in their turn pass the food down the face of the gill on to the ciliated terminal groove. The cilia of this groove move in such a manner as to direct the food toward the mouth in a long line of mucus. Mr. Gray selected the latero-frontal and terminal cilia to study the effects of various ions with respect to their motion. His studies comprised two objects: 1. An inquiry as to the action of various ions upon the activity of individual ciliated cells—*i.e.*, upon ciliary movement as such, and 2, the action of certain ions upon the tissue complex. Writing in the *Quarterly Journal of Microscopical Science* (London), March, 1920, he says with regard to this point: "The absence of certain ions results in the break up of the ciliated epithelium into its constituent cells, although the cilia of the individual cells continue to beat strongly when the cells are entirely detached from the gill and from other cells. It is only in the case of the hydrogen-ion that direct action upon ciliary movements can be studied without injury to the general structure of the gill."

The sea water used by Mr. Gray was obtained from the English Channel, some miles south of Plymouth, and throughout the experiments the hydrogen ion concentration was constant, being about 7.85.

One of the first things noticed was that when this concentration fell below 6 the cilia very soon stopped moving. However, the ciliated epithelium did not break up and when the concentration of hydrogen ions was increased the cilia began to move again.

Mr. Gray studied the effects upon the ciliary motion exerted

by acids, by alkalis, and by neutral solutions. Some of his most interesting experiments had to do with the result of the metallic ions present in sea water. We give a summary of his observations upon this point.

EFFECTS OF METALLIC IONS IN SEA WATER

As far as the action of metallic ions is concerned the most definite point established is that an efficient physiological solution must contain sodium, potassium, magnesium and calcium. In such a solution, whose hydrogen ion concentration is identical with sea water, gill-filaments will remain healthy and exhibit active ciliary movement for more than five days. If any one ion be omitted from the solution, the ciliated epithelium exhibits signs of disintegration after some hours, and the tissue gradually breaks up, although some cilia may continue to beat for as long as three days. If two ions are omitted, the duration of active ciliary movement is from sixteen to twenty-four hours, but the phenomenon of disintegration is very marked. Finally, in solutions containing only one metallic ion, disintegration rapidly sets in and the tissue is very unhealthy after twelve hours; also ciliary movement is usually markedly affected in less than two hours.

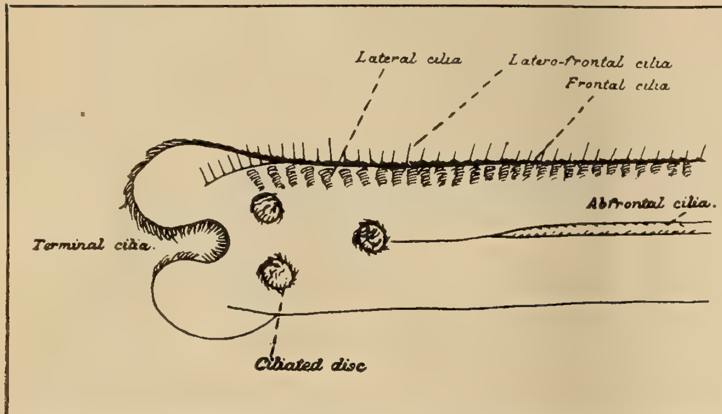


FIG. 1. LATERAL VIEW OF A LIVING FILAMENT OF THE GILL OF *MYTILUS EDULIS* (AFTER ORTON)

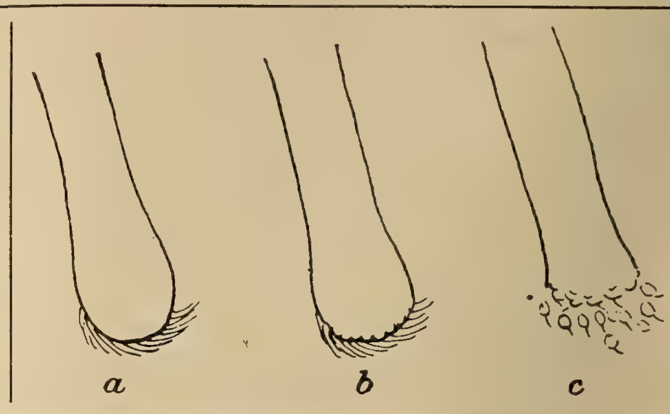


FIG. 4 . PROGRESSIVE DISINTEGRATION OF THE TERMINAL CILIATED EPITHELIUM IN PURE SODIUM CHLORIDE

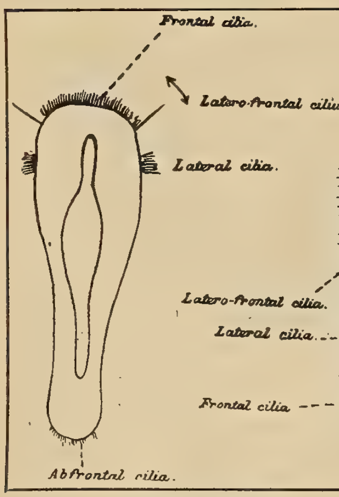


FIG. 2. TRANSVERSE SECTION OF GILL-FILAMENT OF MYTILUS

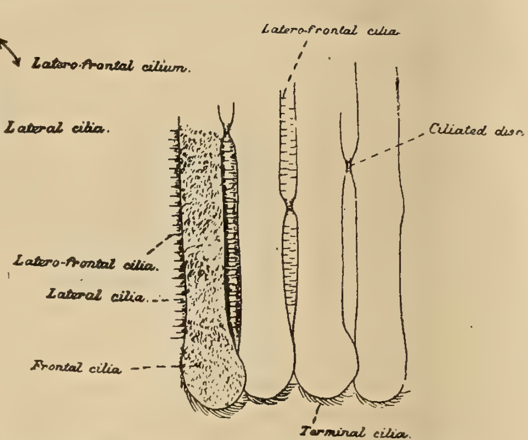


FIG. 3. VERTICAL VIEW OF GILL-FILAMENTS OF MYTILUS

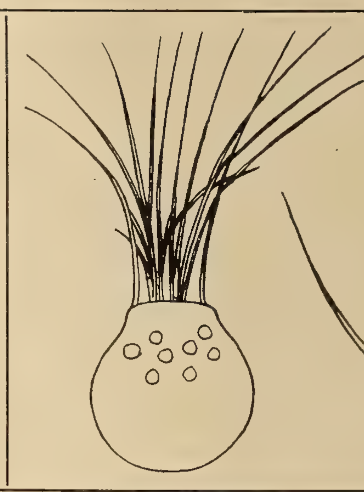


FIG. 5. SINGLE CELL OF LATERAL CILIATED EPITHELIUM

FIG. 6. VIEW OF A SINGLE DETACHED LATERAL CILIUM

It will be noted that very little evidence is obtained on the qualitative value of any particular metallic ion. Sodium appears to be more toxic than potassium. The presence of excess of calcium appears to cause separation of the gill-filaments, and it is possible, therefore, that this ion affects the ciliated junctions or discs. No clear evidence is obtained of antagonistic action between ions; the action of the various metals appears to be additive. Solutions of pure salts are more toxic than binary mixtures, binary mixtures more toxic than tertiary mixtures, while solutions containing Na, K, Mg and Ca form satisfactory physiological solutions.

SUMMARY OF RESULTS

(1) With the exception of the wave action of the lateral cilia isolated fragments of the gills of *Mytilus* continue to function normally in sea water for many days.

(2) Ciliary activity is dependent upon a certain minimal concentration of hydroxyl-ions.

(3) Stoppage of the cilia by acid is reversible by raising the hydrogen content by means of an alkali.

(4) If the hydrogen ion content of the medium is above 9.0 the ciliated epithelium rapidly breaks up into its constituent cells, but ciliary movement does not stop either in the isolated cells or in those which remain *in situ*.

(5) The breaking up or disintegration of the ciliated epithelium takes place in all solutions which do not contain potassium, sodium, magnesium and calcium.

(6) Solutions containing only one metallic ion are highly toxic to the tissue, causing marked disintegration even at low values of the hydrogen ion content. Solutions containing two ions are less detrimental than solutions containing only one. Solutions containing three ions support the tissue in a comparatively healthy state for as much as seventy-two hours; but it is only when the four metallic ions are present that the tissue remains normal and healthy as in sea water.

(7) Little evidence was obtained of qualitative effects of single metallic ions or of antagonistic ion action.

(8) Attention is drawn to the necessity of controlling the hydrogen-ion concentration in all solutions used in the investigation of antagonistic ion action.

Foods Under the Microscope

Some Interesting and Significant Results of the Ocular Analysis of Alimental Substances

By Leon Augustus Hausman, Ph.D., Cornell University

BY means of the unassisted eye alone it is possible, as we all know, to recognize gross structural differences between large fragments of animal and vegetable substances, and to refer them to their proper sources. When, however, such materials are finely ground or pulverized, or made into what seem almost homogeneous pastes, or cakes, then the problem of determining the sources of their constituent materials becomes a different one. And yet, it is not different in principle, but only in kind, for we still use the eye as the chief means of analysis, but with its ocular power enormously increased by the aid of the compound microscope. Through this powerful instrument most substances can be seen to be what they really are, and can be made to yield up the secrets of their derivation. There are but a meager number of foods (liquids of course, excepted) which may not be analyzed by means of the microscope. The presence of extremely minute quantities of a substance may be detected in admixtures, apparently of perfect purity. Thus one part of turmeric has been detected in 448 parts of mustard! Again, from the size, shape, and structure of the pollen grains within a sample of honey it is possible for the microscopist to determine the sorts of flowers which have yielded the original nectar to the bees; and, furthermore, from the form and structure of the crystals in the mass, to say whether the honey has been adulterated with sugar, and to what extent. The field of analysis over which the use of the microscope can be extended by the well-trained scientist is surprisingly broad, and its boundaries are constantly widening. Almost without exception, any substance, save a clear pure liquid, when properly prepared for and examined under the microscope, will render up to the observer the secrets of its original source or sources. Furthermore, by the examination of accurately known quantities of a substance containing adulteratives, the percentages of the various substances present can be accurately stated. This was recently brought out clearly by a series of examinations by the author of samples of different flours where the starch grains could be counted, much as blood corpuscles are counted by the physiologist.

In many cases, of course, the examination of food and other substances requires preparation, and special methods of utilizing the microscope and its accessories. There are many others, however, in which comparatively simple manipulation is sufficient. In Fig. 1 is shown the author's equipment for the examination of substances by means of transmitted light, *i.e.*, light thrown up *through* the substance under examination, which is placed on a glass slide on the stage (B) of the microscope, by the microscope mirror (E). The light is obtained from the lamp (A). Such a method of illuminating is used for starch grains, and similar objects which are transparent or translucent. The substance on the slide is often mounted in water, alcohol, xylol, glycerine, Canada balsam, celloidin, or in various microscopical oils, and is covered with a cover-glass.

Fig. 2 shows the microscope arranged for examination of substances which are opaque or nearly so. In this instance the light which travels up the microscope tube to the eye of the observer cannot pass *through* the object on the stage, but must be reflected upward from its surface by a source of illumination placed above. These are the two primary ways of lighting objects for examination under the microscope. Many modifications of these two fundamental methods of illumination exist, demanding special apparatus. Upon trial, it will be discovered that each substance requires its own special manipulation of preparation, illumination, and magnification to secure the best results.

With the ordinary compound microscope two objectives (B, Fig. 2) called the 16 millimeter and the 4 millimeter; and one ocular (O, Fig. 1) usually the 8 times, or 8 power, will afford sufficiently great magnification for analytical work.

An indispensable piece of apparatus for those wishing to do accurate work in identification, particularly of substances which closely resemble one another, is the comparison ocular. This is fitted to two microscopes, as shown in Fig. 3, in such a way that the two samples under observation reflect their images into the single ocular: each microscope, that is, exhibiting half of its circular field to the eye of the observer.

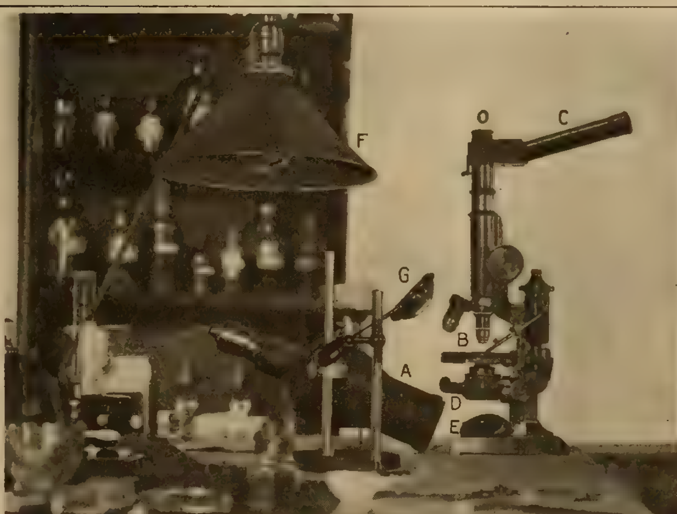


FIG. 1. MICROSCOPE ARRANGED FOR EXAMINATION OF SUBSTANCES BY TRANSMITTED LIGHT

Light from lamp (A) reflected by mirror (E) passes up through the specimen on the stage (B) and thence up the body tube to the eye, at the ocular (O). The extension ocular (C) prevents the necessity of craning one's neck over the ocular.

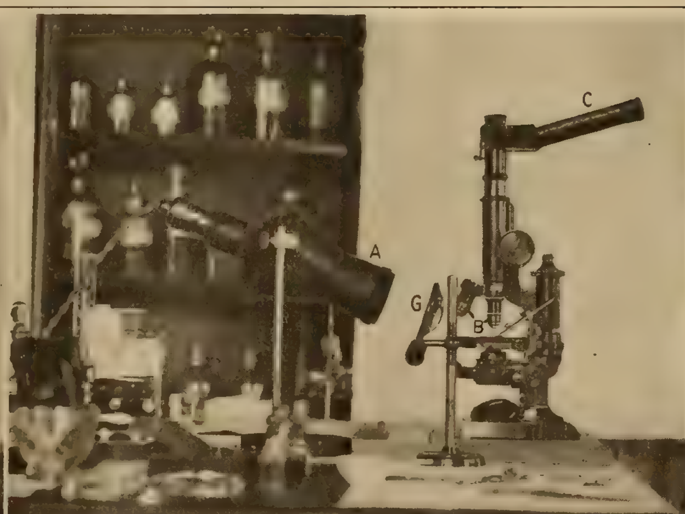


FIG. 2. EQUIPMENT FOR EXAMINING SUBSTANCES THAT ARE OPAQUE OR NEARLY SO

The lamp (A) has been elevated above the level of the stage, and its light is focussed on the object by the condensing lens (G). The sub-stage mirror has been turned aside so that no light from it enters the microscope tube.

Thus two preparations, on slides, can be enlarged to equal magnitudes and brought close together for intimate and detailed comparison within the same microscopic field. The utility of such a device will be at once apparent. Figs. 17, 18 and 21 to 24 were all made from such a comparison ocular.

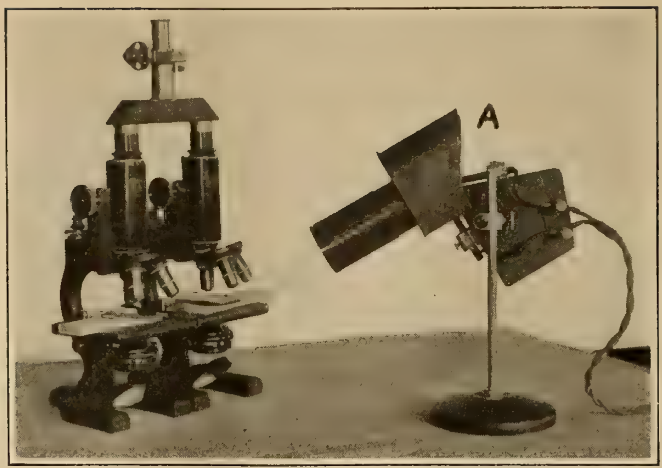
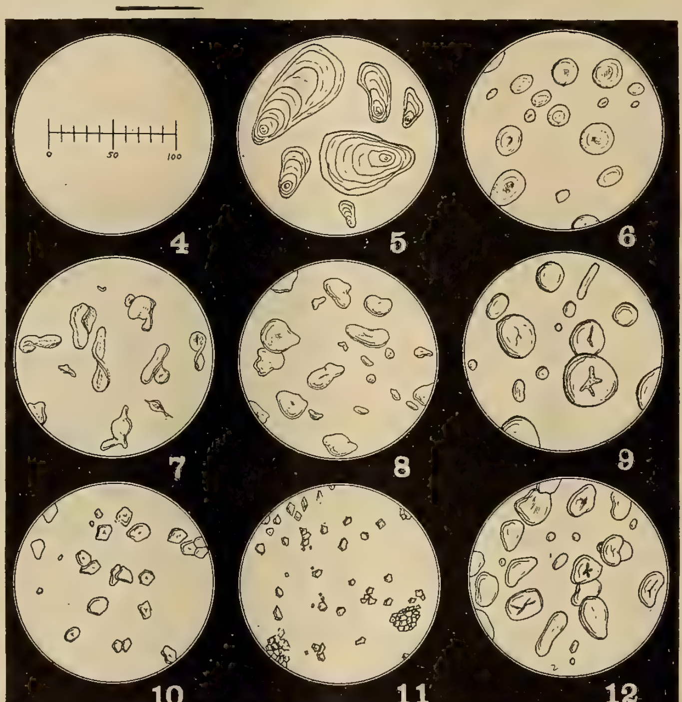


FIG. 3. TWO MICROSCOPES FITTED WITH A COMPARISON OCULAR

The ocular itself contains a scale for delicate measurements. (See Fig. 4.) The objects undergoing comparison are being viewed by reflected light thrown from the arc lamp (A).

The microscopist who is called upon to examine and pronounce upon the constituents of a great number of diverse substances must have a fundamental knowledge, at least, of the appearance of the various basic animal and plant tissues. Some knowledge of botany is here presupposed, as well as of zoology, and the form and structure of certain crystals of chemical substances. The comparison ocular often makes easy the identification of unknown fibers, cells, or crystals. In some papers of recent publication, the author has pointed out also how a knowledge of the microscopic structure in the hair of the fur-bearing mammals can be used to identify the species of mammal from which the hair was derived, and in this way to detect imitations.

One of the most important substances from the food point of view is starch. It is one of the most widely distributed elements in the content of plant cells. Careful researches by botanists have shown that the starch grains of any particular plant are characteristic of that plant in shape, size, and structures of various sorts. Thus each plant bears its own characteristics in its starch grains, and these may therefore indicate their origin. The value of such differences in starch grains to the microscopist is apparent. Since starch grains are present so universally in vegetable substances, it is almost impossible to include, in a food preparation any vegetable substance, without including also its tell-tale starch granules. And if, by chance, or design, some portion of any plant is used (such as the husk, etc.), where starch grains may not be present, the structure of the cells of which the tissue is composed can be just as readily used as a basis for identification. An eminent microscopist recently remarked to the author: "Very few secrets, dealing with the composition of material things, are safely hidden from the man with a microscope."



FIGS. 4-12—A STUDY OF STARCH GRANULES

4, Scale for comparing sizes of starch granules. Such a scale is placed in the ocular of the microscope. *5*, Potato Starch. *6*, Wheat starch (raw). *7*, Wheat starch (boiled). *8*, Wheat starch (baked). *9*, Rye starch. *10*, Corn starch. *11*, Rice starch. *12*, Bean starch.

Fig. 5 shows the appearance, under transmitted light, of a very common starch, potato starch, which is all too common as an adulterant of many kinds of foods. The grain is usually described as resembling an oyster shell, and surely a better simile could not be found. In this, as in many other starches, the grains vary much in size, but whatever their magnitudes, their characteristic form and markings remain constant. It is the characteristics of the form and the structure which the microscopist looks for, in identifying starches, rather than for size. However, the *average* sizes of starch grains from different plants (or different parts of the same plant) can be compared, often with results of value in establishing, or supporting, identities or differences. In Fig. 16 is shown a sample of a soluble cocoa, which, it can be seen, is mixed with potato flour. Since this is a typical sample taken from the well-mixed "cocoa" the true proportions of the pure cocoa and the potato flour can be inferred. Notice that the cells, composing the cotyledons, or parts of the cocoa seed, are as large as the potato-starch grains themselves, and that the cocoa-starch grains are very minute. Such an enormous adulteration of the cocoa with potato could not, by any other means than microscopical examination, be so easily detected. Fig. 22 again, shows another easily adulterated food, or rather condiment, ginger, which is often mixed with potato- and sago-starches.

The question has often been asked whether it is possible to distinguish between food substances which have undergone the process of cooking, in various ways. In most cases, yes. Heat, either moist or dry, affects starch grains, as well as other vegetable and animal substances in different ways, and the identification of such modified substances is merely a matter of study. For example, compare Figs. 6, 7 and 8. Fig. 6 shows raw wheat starch as it can be seen in flour. Fig. 7 shows the appearance of the starch grains after having been boiled, *i.e.*, as in puddings; and Fig. 8 their appearance after having been baked, as in bread or cake. In dry heat the grains simply split up, but in any preparation except one completely charred into carbon, retain enough of their "personalities" to be recognizable. In wheat starch, the raw grains are discoidal, with the flat faces bearing an almost circular outline (Fig. 6). The striations are absent, or nearly so, and the grain appears as though made of a glassy substance. Wheat flour is often substituted by, or largely adulterated with, potato flour. The detection, of course, is simple.

The starch granules of rye, as seen in the rye flour (Fig. 9) closely resemble those of wheat. Here is a case where careful study has to be made, and measurements taken with apparatus specially designed

for minute measurements under the microscope. The use of the comparison ocular is in such cases a necessity of indubitable identifications are to be made.

In corn flour the characteristic form of the starch granules at once proclaims their origin, being slightly polygonal in form, with rounded angles (Fig. 10). A central depression is present in most of the grains.

Fig. 11 shows the appearance of the starch granules of rice flour. Here the individual grains are distinctly polygonal, with sharp angles and edges, many of them being irregularly pentagonal. Like the starch grains of oats, they are often found coalesced into larger compound grains. From oat starch, rice starch is to be distinguished by the smaller size of its individual granules.

Bean flour is often, like potato and barley flour, used as a substitute for, or an adulterant of, wheat flour. Fig. 12 depicts the appearance of the bean-flour starch grains. Beans of different varieties, show corresponding differences in their starch grains, but in general, the large likeness between bean starches of all sorts was early recognized.

Coffees are among the food materials most largely adulterated, and here the microscope is an invaluable aid in detecting at once the presence among the coffee-bean fragments, parts of other vegetable substances. No starch is present in the coffee bean, but other characteristic structures are there which serve as guides to identification. In Fig. 13 we have the appearance of roasted and ground coffee. The most characteristic portions of the bean structure are the dark, angular cells forming the interior substance of the bean itself (endosperm). These fracture irregularly, as shown. In the unroasted coffee there are present in each of these cells several oil globules, but these are driven off by the heat during the process of roasting. The long, fusiform cells of the outer investiture of the coffee-bean are also present in the prepared coffee. Compare now the sample shown in Fig. 14. Here there has been added to the coffee, chicory, which though roasted and ground with the coffee and thoroughly admixed still reveals its presence unerringly, through the characters of its cells. The extraneous matter in this sample can be seen by comparing it with Fig. 13. In Fig. 15 is shown still another "coffee" adulterated still more by the addition not only of chicory but also of ground and roasted acorns. The element proclaiming indubitably the presence of the latter adulterant is the starch granules, with their characteristic stellate black figure in their centers, an appearance due to the way in which each grain diffuses the light from the microscope mirror. The degree of adulteration of this particular sample can be estimated with fair accuracy from the multitude of acorn-starch grains.

FIGS. 13-18—COFFEE, COCOA, TEA AND HONEY

13. Roasted ground coffee. 14. Coffee and chicory. 15. Coffee, chicory and acorn. 16. Cocoa and potato starch. 17. *Left*: lower epidermis of tea leaf. *Right*: lower epidermis of plum leaf. 18. *Left*: honey. *Right*: sugar.

FIGS. 19-24—BERRIES, FRUIT, TOBACCO AND MILK

19. Strawberry. 20. Cherry. 21. *Left*: red currant. *Right*: apple and turnip cells. 22. *Left*: ginger. *Right*: sago and potato starches. 23. *Left*: lower epidermis of tobacco. *Right*: lower epidermis of rhubarb. 24. *Left*: rich milk. *Right*: poor or diluted milk.

Tea also has its adulterants (as what food does not!), and here again detection is not difficult. The detection of leaf adulterants in tea is based largely upon the differences in the character of the epidermis, or "skin" of the leaf. In the lower epidermis, especially, comparison is easy, for this lower integument of all leaves which are associated with tea as adulterants, bears large guard-cells surrounding the stomata, or breathing pores in the leaf. These, together with the shape of the cells of the lower epidermis itself, offer almost infallible indices to the species of plant from which the leaf was derived. In Fig. 17 are shown two specimens of lower epidermis of leaves, brought together for accurate comparison by means of the comparison ocular (Fig. 3). The left epidermis is that from the common china tea (Camellia), while the right specimen is from the leaf of a plum, found in a sample sold as strictly pure tea. The difference is obvious, and the detection simple.

Figure 18 shows another interesting and significant comparison (through the comparison ocular), that of the crystals of

honey (left sample) and of cane sugar (right sample). Honey may be adulterated with cane sugar, as well as with various starches. In any case the clear cut honey-crystals serve for differentiation. Note how large and massive are the sugar crystals. Within honey samples there are found the pollen grains from the various flowers visited by the bees.

Preserved fruits in the forms of jams, marmalade, etc., are easily analyzed under the microscope, for here the various structures of the pulp and skins of the fruits used can be readily spread out upon the microscope slides, and identifications made by means of the comparison ocular. Fig. 19 shows characteristic structures in the strawberry, as seen in the fruit after it has been made into jam, and Fig. 20, of the cherry. Turnip and apple are commonly used as adulterants in all sorts of fruit preserves. In Fig. 21 is depicted the appearance (on the right) of the large, bulky cells of the pulp of the apple (below), and of the turnip (above). On the left are cells from the red currant, as they appear in jams.

Tobacco adulteration offers another fertile field for the operations of the dispenser of adulterated commodities. Many varieties of leaves are used to dilute ground tobaccoes, or tobaccoes sold for manufacture into cigars. These may be distinguished by the microscope on the basis of their different cell structure. In Fig. 23 is shown, on the left, the lower epidermis of the tobacco leaf; and on the right the lower epidermis of the rhubarb leaf, commonly detectable in some varieties of tobacco. Note how readily the shape of the crescentric cells (guard-cells) surrounding the stomata or breathing pores of the leaf, can be used as distinguishing features.

Not only can the microscope be used to detect admixtures of extraneous matters into any given pure substance, but also to determine the comparative richness of certain elements in various foods. Thus milk samples can be readily graded, care being taken to estimate the number of fat globules present in a given amount. Fig. 24 shows, on the left, a sample of full rich milk, and on the right a sample of poor, or diluted milk. In the latter case see how the paucity of fat globules tells a tale of inferiority which might not be capable of determination except through the use of much less expeditious procedure than examination in the microscope.

The first test of many substances should always be the microscopic one. In most cases no other will be necessary.

Searching the World for New Food Plants

A 9,000-Mile Trip Through Africa in Quest of New Fruits, Nut Plants and Forage Crops

DR. H. L. SHANTZ, a government botanist, has recently returned from a 9,000-mile trip through darkest Africa, the purpose of which was to study the native agriculture with an eye for new fruits, nut plants, forage crops, especially those adapted to our South and West, new sorghums and especially wild sorghum grasses of types similar to Sudan grass. This grass has proved such an important forage crop in the semi-arid districts of the western part of the United States that ten million dollars' worth of it was grown last year.

Dr. Shantz and Mr. Reval, of the Smithsonian Institution, made the acquaintance of many agriculturists and men in various sections of the Dark Continent who can in the future be useful to the department by sending in plants which are desirable and which could not otherwise be obtained. The direct tangible results consist of seeds or living material of more than 1,600 different species or varieties of plants, many of which had not previously been imported into the United States, and from which it is only reasonable to suppose some important grain, forage or fruit crops may be developed.

The party sailed directly to the Cape Verde Islands off the coast of Africa, and from there to Cape Town. The journey of nearly 9,000 miles was made almost entirely through the heart of Africa, sometimes 1,000 miles inland, with occasional expeditions to the coast for observations of Zanzibar and other islands, and at Lourenco Marques and Beira.

In Cape Colony, Dr. Shantz went east to Port Elizabeth, where the famous Addo bush is found. He obtained many plants, one of the most interesting being the Speckboom, one of the most important foods of the elephant. This plant covers whole hillsides with its succulent growth. Cattle and sheep are fond of it, and there is a chance of its becoming of value in southern California. Speckboom will grow under practically the same conditions as the utterly worthless chaparral of southwestern California.

THE EXPEDITION GOING INTO CAMP ON THE KAFUE RIVER IN NORTHERN RHODESIA—A REGION RICH IN NATIVE FRUITS

The explorer then passed northwest over the Karroo desert, similar to ours in the Great Basin, but differing in that most of the plants form excellent forage for sheep, cattle, and ostriches, and it seems probable that some of the more desirable of these desert plants may be utilized in our desert country to improve the range.

The route lay east and north through the Kimberley diamond region and the gold mining country of Johannesburg and Pretoria, the capital of the Union of South Africa.

Much of the country which Livingstone painfully traversed something more than half a century ago, is now open to the traveler with comparative comfort, if he rides on the South African railway. There are still fastnesses, however, where the party was compelled to tramp as much as 800 miles away from any railways. The route often lay through the jungle, where there are no roads at all.

Long stretches were covered by steamer, many of them belonging to primitive transportation systems where the traveler is required not only to buy passage, but also to provide himself with bed, shelter, food, and even the wood with which to cook it.

In the center of the great Transvaal agricultural area corn, known as mealies, is the chief crop. Dr. Shantz, to his surprise, came upon one of the most important varieties, our own Boone County White, a gift from America of considerable value to the farmers of the Transvaal. It was like meeting a friend from home.

In the low veldt at Nelspruit are large orchards of subtropical trees and fruits, many varieties of which have not been grown in the United States. Among them are some particularly desirable mangoes, adaptable to Florida, which the Department has wanted for several years.

The party traveled over

WILD COTTON IN THE UPPER SUDAN

This was the basis of our American-Egyptian cotton which produces a $20,000,000 annual crop in regions not formerly arable

A FIELD OF NATIVE AFRICAN SORGHUM GRASS

It was from such a source that the United States Department of Agriculture brought the seed which has developed an industry worth many million dollars a year on semi-arid soil of the Southwest.

the highlands of Portuguese East Africa, which have been developed by the Mozambique company into one of the most important agricultural sections of East Africa. It proceeded across Southern Rhodesia to Bulowayo and Victoria Falls. At the latter point many of the fruits concerning which Livingstone wrote enthusiastically, were found and tasted. The modern Livingstone sent the seeds to the Department of Agriculture in the hope that they might prove useful in this country.

Dr. Shantz spent a month at Kafue in the north of Northern Rhodesia, where a delay was caused by the sickness of two members of the party. Word was received of a railway wreck on the Congo railway, in which two members of the original party were killed and two injured and forced to return to America. This news, coupled with the sickness in camp, was the darkest part of the trip and threatened at one time to terminate the expedition, so far as Central Africa was concerned.

In spite of the hardships, the party decided to keep on through the Congo. Here for the first time the men encountered a lack of adequate provision for traveling. Practically no accommodations and no provision for food for travelers were found, although in some cases the captains on the ships on the Congo were kind enough to allow the travelers to mess with them. At certain points grass huts had been provided as temporary quarters.

In Zanzibar, principally noted for the production of cloves and for the extensive groves of cocoanut palm and many tropical and sub-tropical plants, Dr. Shantz obtained and sent home seeds and plants of a number of important fruits. He also collected samples of the staple grains and legumes grown in various parts of the East Coast of Africa which are brought

STEAMER ON THE NILE USED DURING THE TRIP THROUGH AFRICA

in by the natives and sold in the Zanzibar market places.

The explorer made an extensive trip into the desert country north and east of Mt. Kenia, and collected the principal varieties of tropical crops grown by the natives in this section. Here he also obtained a notable nut plant called telfairia, which forms a large gourd two or three feet long containing many seeds of a delicious nutty flavor, about one inch in diameter and one-quarter of an inch through, and which tastes something like our butternut. Although this plant has not yet been tried in this country, it seems probable to the experts that it can be grown here or at least in the Philippines and possibly in Hawaii and Porto Rico as well.

Dr. Shantz brought with him about 3,000 photographs in addition to the many plant specimens. The living plant material is now growing in the various plant introduction gardens of the Department preparatory to being distributed later to experiment stations and experimenters in different parts of the country.

DR. SHANTZ, AT THE LEFT, PERCHED ON AN ELEPHANT KILLED NEAR THE CAMP AT PORT ELIZABETH, CAPE COLONY

AN "OVEN PLANT"

THE wild flower known as cuckoo-print (Arum maculatum) may be regarded as a sort of oven plant. It lives in damp and shady deciduous forests and blooms in early spring, while the sun is still able to penetrate the bare branches. The blossom, or rather the club like support of the flowers, consists of a greenish white protecting leaf, wide open at the top but coming together in a pot like shape at the bottom. Beneath the club-shaped portion of the spadix are several rows of stiff hairs extending to the wall of the closed portion of the enclosing bract forming a sort of net beneath which are several stamens and the pistil. Pollination of the pistil is accomplished by insects which pass through the thicket of hairs into the kettle-shaped portion of the flower but do not get out again at once. Within this space there is a higher temperature than without on account of the livelier respiration of the plant. The greater warmth of the spadix can even be felt when the tongue is placed against it. In some species, indeed, difference of temperature is actually as much as from 10 to 20° C. higher.

The numerous little gnats which have gained an entrance through the forest of hairs to this comfortably heated apartment, remain captive for a few days, regaling themselves meanwhile with the drops of honey spread before them and later, with the flowery pollen which has ripened in their efforts to get this they accomplish their destined purpose of fertilizing the pistil and now find themselves free to depart, since the surrounding hairs which hitherto prevented them from escaping have shriveled away.

PAPER FABRICS AGAIN

DURING the war a great deal was heard of the use to which Germans were putting paper including paper bandages which proved to be strong and pliable enough for the purpose, paper clothing, some of which later appeared in other markets, and a variety of cloths particularly useful in taking the place of coarse fabrics. German woven paper bags and sacks are beginning to make their appearance in England in considerable quantities and there seems to be no doubt of their strength and general utility. They are reported to be clean, well made and of light weight, and are scarcely distinguishable from jute.

INSPECTING A BANANA SHAMBA IN THE UPPER BELGIAN CONGO

Possibly some of these may be found resistant to the banana disease. Seed of a wild banana adapted to ornamental purpose, were brought in by the explorer. Because of the remoteness of the region to have brought banana shoots would have required a special expedition.

Flavors, Odors and Infra-Red Rays*

Measuring Degrees of Taste and Smell with the Olfactometer and the Saporimeter

By G. Hamelin

OF all the senses possessed by animals, taste and smell are the most useful, for various reasons. In the first place they guide them in the search for food and in decision as to the latter's quality; furthermore, they control those important reflexes by means of which the digestive secretions, such as the saliva, the gastric juice, etc., are governed, and they augment the respiratory and muscular reflex actions. They appear to be in a rather retrograde condition in mankind: The human embryo, for example, has the so-called "taste buds" or papillae distributed as far as the opening to the oesophagus, just as fishes do. The fair sex, to be sure, finds perfumes attractive, and statistics show that there is a steady increase in the sale of toilet water, etc., and the sterner sex is still devoted to fine wines and tobaccos, despite the recent increase in their cost. We are still ignorant of the true nature of the factor which determines sapidity and odor. It is undeniably true that these qualities are connected with the emission of molecules of matter or ions, but to say this does not afford an explanation. For this reason I was greatly surprised to discover, in a treatise by M. Charles Henry, called *Rayonnement, Gravitation, Vie* (Radiation, Gravitation, Life) and published by The Institute of General Psychology, certain pages to which this title gives no clue and which carry with them an implication of a complete solution of the problem, since their author sets forth in them his calculations concerning the tastes and the odors of various sapid and fragrant bodies.

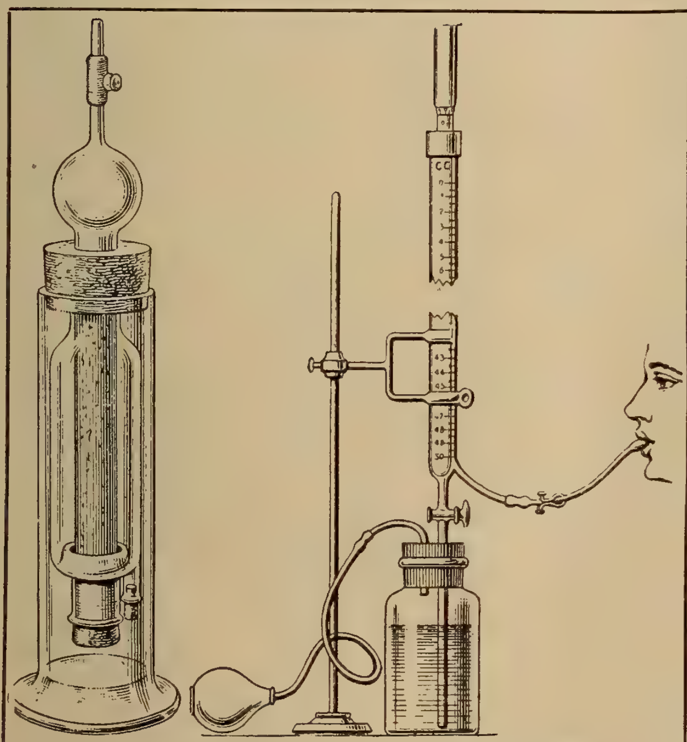


FIG. 1. OLFACTOMETER. FIG. 2. SAPORIMETER

The olfactometer is used to calculate the weights of the amounts of vapor which have passed in succession into the tube. This weight is the upper limit of the perceptible limit of an odorous liquid or solid body. The saporimeter is an apparatus employed for testing wines, beers, etc.

Hitherto this problem has been attacked only by physiological methods. Investigators have sought to measure the smallest perceptible degrees in taste and in smell, and to understand the psycho-physical laws concerned, *i.e.*, the relations between certain degrees of sensation and various concentrations of liquids or vapors, the times of reaction required, etc. This was indeed the only possible method of obtaining results, and this must necessarily be the starting point in any endeavor to determine the relations between these poorly understood senses and the better known ones of sight and sound. In order to measure the "perceptible minima" of odors and savors, M. Henry has invented his well-known olfactometer and saporimeter. The former (Fig. 1) consists of a glass vessel traversed by two tubes, one of which slides into the other: A paper tube stoppered at the bottom, and inside of this a glass tube gradated in millimeters, whose upper part emerges from the vessel so that it can be introduced into one nostril while the other is closed. In the vessel are placed a few drops of the odorous liquid to be examined; as soon as the atmosphere of the vessel is saturated it is closed by a test tube provided with a stop cock. The operator notes the time and then lifts the glass tube, being careful to have the movement proceed at a uniform rate; at the instant when the minimum sensation is produced he notes the time, and stops the motion of the glass tube. The weight of the vapor which has passed successively into the tube can be calculated by means of the height and duration of the lifting motion with the apparatus as a constant, and having also a knowledge of the rapidity of evaporation of the odorous body at the temperature of the experiment. This weight represents the upper limit of the perceptible minimum.

The rapidity of evaporation of the liquid at the temperature of the experiment is given by a vapor scale. This is an extremely sensitive aerometer whose nickel plated steel rod about 0.5 mm. in diameter, moves in a vessel containing alcohol along a scale divided in millimeters. This apparatus is so delicate that by its means it is possible to detect even the smallest adulteration in the composition of the perfume, provided the velocity of evaporation of the pure perfume is sufficiently well known.

I visited M. Henry who is the head of the Laboratory of the Physiology of Sensations at the Sorbonne, in order to request him to throw some light upon his discovery and give me some explanation of its origin. He called my attention to the fact that it had been quite easy to make an improvement in his olfactometer merely by replacing the movement of the tube by a photographic shutter or diagram, so arranged as to leave uncovered, for various known amounts of time, a variable and known area of paper; through this shutter there is allowed to pass at the maximum tension a minute quantity by weight of the odorous vapor to be examined; this fractional weight is the same for all vapors, an important fact which was quite unsuspected, but which has been indisputably established by experiment. In this manner it is possible to determine with absolute precision the perceptible minima of various odorous gases.

"This method of research," M. Henry remarked to me, "is all the more interesting, since the method ordinarily employed by many physiologists, which consists in diluting perfumes with alcohol and placing a drop of the mixture in a glass vessel, whose exact content is known, is quite incorrect. Such a method, moreover, is frequently found to give results which contradict those obtained by the comparative methods of Zwaardemaaker, which consists in uncovering known areas of a porous tube saturated with perfume. This latter process yields results absolutely in agreement with mine, making use, as is evident, of a device which closely resembles my own olfactometer, though founded upon a very different principle."

The saporimeter (Fig. 2) consists of a simple tube containing

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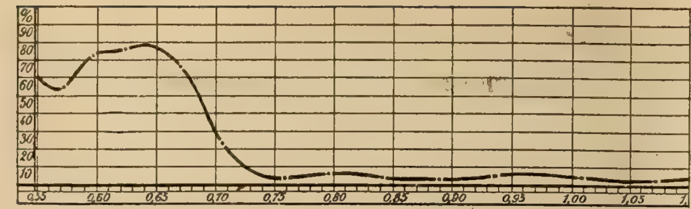

FIG. 3. EXTINCTION SPECTRUM OF CHLOROPHYLL (D-3.2 MM.), BY DONATH

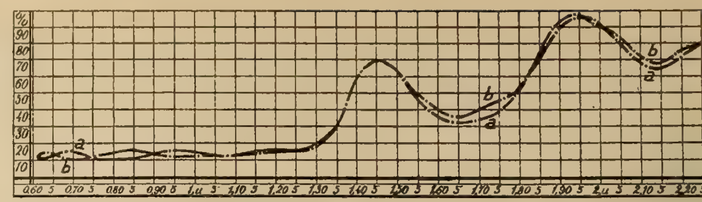

FIG. 4. ABSORPTION SPECTRA OF DISTILLED WATER (*a*) AND POTASH ALUM (*b*)

100 cm. and graduated from the top downwards. It is provided at its upper orifice with a needle valve and at the bottom with an ordinary stop cock; it is the former which is the essential part of the apparatus, since it enables the operator to control at will the access of air into orifices of capillary dimensions and consequently to retard the flow of the liquid at will. It bears a scale which enables the experimenter to reproduce at will the sections of the access of air and, consequently, the desired velocity of flow. The lower end of the tube is provided with a glass nipple which can be cleaned and which is connected by a rubber joint. Let us now suppose that this tube has been filled with wine and that the needle valve has been fitted to its orifice. The lower stopcock is now opened and a stop watch is set going at the instant when the liquid reaches the mouth of the experimenter; the interval of time required for the subject to receive the first sensation of taste, whether sour or sweet, is first noted and next the interval required before a second sensation of different quality is perceived, and finally, a third sensation which differs from the first two, after which the experiment is stopped. These intervals of time enable the operator to discover the volumes of the wine which correspond to the different sensations, while by reading the graduated tube he learns the volume which corresponds to the final sensation.

This instrument has received a practical application in those industries where taste is a factor, as in the making of wines, beers, etc.

When it is desired to make a study of any given flavor in various degrees of concentration, two tubes are used, in one of which is placed the liquid in question at any given degree of concentration, while in the other tube pure water is put; the two liquids are thoroughly mixed with each other by a mechanical apparatus. By this means it is quite easy to determine the degrees of concentration which correspond to different degrees of sensation.

M. Henry had long suspected that there is a relationship between tastes and odors, on the one hand, and the infra-red spectra, on the other, when he came across the works of Bruno Donath upon the extinction spectra of the ethereal oils (1896) and of Coblentz concerning the extinction spectra of gas and of vapors in the infra-red. The spectra given by Donath (Fig. 5) which apply to the essence of turpentine and to the oils of sassafras, juniper, rosemary, olive and petroleum between 0.7 μ and 2.7 μ are remarkably analogous. But if one takes suitable precautions to eliminate the sensation of odor, *i.e.*, by clamping the nose, one finds that all these substances have an *almost identical taste, namely, a bitter sweet taste;* taste, therefore, appears to be a function of the infra-red radiations. In the same way it has been discovered that the products of the distillation of petroleum for which Coblentz found infra-red spectra remarkably concordant have tastes and odors which are nearly identical. Potash alum, whose absorption curve differs very little from that of distilled water, according to Donath (Fig. 4) does not differ from the latter in taste, except by means of its styptic character, which is in reality a tactile sensation. Furthermore, in studying the intensity of metallic odors M. Henry found that this decreases in the same ratio as the emissive power of the metal, *i.e.*, in an opposite ratio to the electrical conductivity and to the lengths of the waves emitted; this indicates that the intensity of a metallic odor bears a relation to the intensity of minute infra-red radiations. It appears to be an indisputable fact, therefore, that taste and odor are thermic senses bearing a specific relation to wave lengths.

But it is true, moreover, that the experiments of Lefèvre with respect to the radiation homœotherms have led to the view that our own radiation is practically the same as that of a black body at 273° + 37° absolute, with a maximum λ emission of 9.48 μ. The radiations of taste and odor are of the same order of magnitude as our own radiations; the latter are absorbed or not absorbed as the case may be by bodies in contact with the papillae of taste and the olfactory fissure. It is thus clearly demonstrated that taste and odor depend upon modifications caused in our own radiation by means of infra-red spectra.

This theory at once explains a great number of facts such as the "toning" or "shading" of odors and of tastes by means of concentration or increase of temperature, since concentration causes the enlargement of the bands of absorption and causes new ones to appear, while temperature moves the rays towards the large λ; the carbides of the aromatic series are crossed by bands, while those of the fatty series are not so crossed.

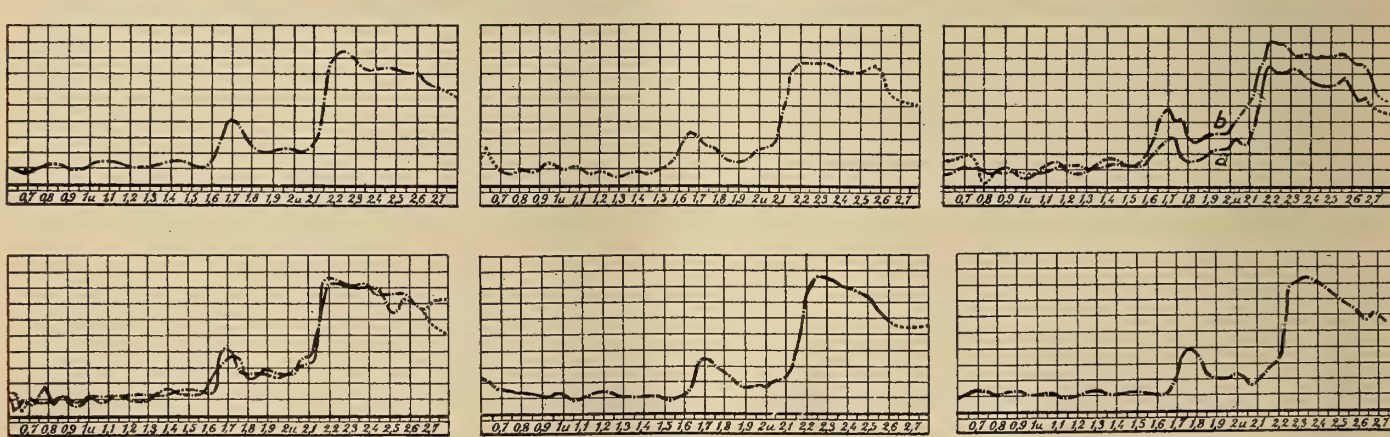

FIG. 5. OTHER EXTINCTION SPECTRA BY BRUNO DONATH

Top row, left to right: Oil of turpentine (d-0.75 mm.); oil of sassafras (d-0.75 mm.); oil of juniper (*a*, d-0.45 mm.; *b*, d-0.9 mm.). *Bottom row:* Oil of rosemary (d-0.75 mm.; *a*, Italian; *b*, French); olive oil (d-0.75 mm.); petroleum (d-0.755 mm.). Observe the striking analogy between the curves representing these spectra of substances which possess an almost identical taste when care has been taken to eliminate the sensation of odor.

The radicals common to acids or to sweet substances, the free anions of salty products, the cations of sweet and bitter substances, etc., are characteristically exhibited in the spectra. This offers another verification of the principle of the theory.

To fully establish the theory it was only necessary to take into account the principles and general facts of the physiology of sensations, to compare the known facts concerning the sensations of taste and odor with those known concerning the sensations of sound and color, and to find a connection between tastes and odors and the infra-red extinction λ. When all this had been done an effort was made to verify the theory by reproducing the tastes and odors of bodies by means of calculation.

Unfortunately, we have as yet but few data upon the infra-red spectra—it is very probable, however, and it is to be hoped that future discoveries may make it possible to find corrections in the calculated constants; especially since M. Henry has been able to obtain formulas which are undoubtedly approximately correct . . . . .

Sensations depending on vibrations.—In the case of those sensations which are caused by vibrations there are three fundamental quantities to be determined: 1. The *field*, *i.e.*, the

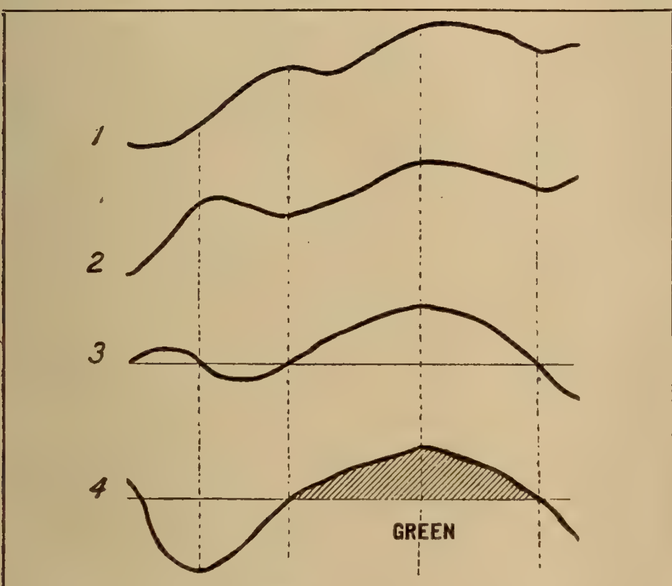

FIG. 6. CURVES OF SENSIBILITY

Curve 1 is the integral curve of curve 2 which is the curve of Uhthoff which represents the variation of $\Delta\lambda/\lambda$ in function of λ. Curve 3 is the curve of the second sensibility or the curve derived from curve 2. Curve 4 is the curve derived from curve 3 or the curve of the third sensibility.

interval within which the radiations concerned in the sensation under consideration are exerted and at the end of which the sensibility becomes once more of very slight magnitude, or a magnitude corresponding to the magnitude of the initial radiation—*i.e.*, the interval between the extreme radiations; or, perhaps, it would be better to say, for certain psycho-physical reasons, the logarithm of this interval.

2. The *period*, which makes definite a precise quality of the sensibility.

3. The *tone* or *interval* which defines a quality of the sensation.

The theory of music.—It is evident that the theory of music is merely a special application of a more general physiological theory. The theory of the representations enables us to calculate intervals of λ radiations by the expression $1 < a^{-na} < 2$**, a being equal to $\frac{3}{2}$ and n being the series of numbers from 1 to 8. These intervals differ very little from $2^{n/8}$, n representing the values from 1 to 8—these are the subdivisions of the octave.

**$a^{-na} = \frac{1}{a^{na}}$

M. Henry has applied the term *méride* to the interval $2^{\frac{1}{8}} = 1 < \left(\frac{3}{2}\right)^{-\frac{3}{2}} < 2$. He designates the intervals for the successive values of n by the terms *di-*, *tri-*, *tessaro-*, *penta-*, *hexa-*, *hepta-*, and *octo-méride;* he designates the fractions of the *méride* ½, ⅓, ¼, by the terms *hemi-*, *trito-*, and *tetrato-méride.*

If we are able to arrive at a knowledge of the intervals in the case of any sensation, we can find without difficulty the periods and the fields by multiplying the value of the intervals by 6 and 6^2.

In order to find the limits of the effective field in the case of colors, we utilize the fact that the slightest visible λ radiation is in the vicinity of 393 $\mu\mu$ and that the second sensibilities of establishment are practically nil at the beginning and at the end of the field, in other words in the extreme hemi-mérides. . . . .

We thus obtain, λ and λ_o being the extreme λ, for the log. λ_1/λ_o the value 0.221, or a hexa-méride. In the case of colors the period is the méride in which practically each second sensibility is characteristic; the tone is 1-6 of the méride, and it is possible in practice to distinguish on the average, six tones in a méride. We have just been speaking of sensibilities of establishment; it is necessary to give the reader an idea as to the nature of these new quantities, which have a considerable degree of practical interest and which are destined to play one of the most important of rôles in future researches concerning the physiology of sensations.

Sensibility is by definition measured by the increase of the sensation or of the motor reaction connected with the increase of the stimulus: light, color, sound, etc.

Uhthoff has measured the sensibility to the change of tint in the spectrum; the sensibility to each radiation λ, before it attains its regular intensity passes through a value of establishment; it was these establishment values which Uhthoff measured. But it has been found that these values (or magnitudes) proceed at the same rate as compared with wave lengths as the instantaneous energy exhibited by the radiations of black bodies subjected to any sort of thermic disturbances whatever. This fact establishes the existence of a striking analogy between nervous radiation and electro-magnetic radiation.

Uhthoff's curve is No. 2 in Fig. 6; this is the ratio $\Delta\lambda/\lambda$ in function of the radiation λ, $\Delta\lambda$ being the smallest difference of wave lengths perceptible for a λ radiation. Curve No. 1 is the exact sum of the small areas which form the elements of curve No. 2; it represents the stationary sensations of the successive λ.

Curve No. 3 is the curve derived from the one preceding; it is the curve of the sensibility to the sensibility measured by the latter, or the *second sensibility*. Curve No. 4 is the curve derived from curve No. 3; it is the curve of the sensibility to the sensibility No. 3, or the *third sensibility*. This curve (No. 4 in Fig. 6) enables us to define mathematically for the first time the *complementaries*, *i.e.*, those colors whose sensations annul each other; they are the colors whose third sensibilities of establishment are of opposite signs, these sensibilities being counted starting with the small λ or with the large λ since green has no complementary color.

A SCALE OF TASTE

The varieties of tastes commonly given are bitter, salty, sweet, sour (or acid). The perceptible minima of these agree respectively to the following concentrations:

3×10^{-6}†; 2.5×10^{-3}; 4.9×10^{-3}; 1×10^{-4}

From this scale the alkaline taste and the insipid taste are omitted although they may occasion quite violent physiological reactions, even causing vomiting. M. Henry finds the perceptible minima to be 4.55×10^{-4} in the case of an alkaline taste and 1.66×10^{-2} in the case of the insipid taste (dialyzed albumen). We may arrange sensations of taste in the order of

†$3 \times 10^{6} = 3/10{,}000{,}000 = 0.000{,}000{,}3$. As we see, a number multiplied by a negative power of 10 is equal to the quotient of this number divided by a power of 10 equal to the preceding, but positive instead of negative.

their increasing radiations in the following scale, bitter, salty, sweet, and acid. But since alkalies when strongly concentrated are bitter and since the insipid taste is the complement of the salty taste, we obtain eventually, arranging them according to their increasing radiations, the following scale: bitter, alkaline, salty, sweet, acid, insipid—the last three tastes being the complements respectively of the first three.

Donath's extinction spectrum of chlorophyll (Fig. 3) enables us to calculate the period of tastes. This substance occasions a persisting sensation of bitter following a first sensation of salty. Starting with $\lambda = 0.75\ \mu$, this spectrum exhibits a series of undulations which gradually neutralize each other. All the λ of maximum energy which concur with the bitter are distants of the ratio 1.185. *i.e.*, of the di-méride; the di-méride, practically ¼ of the octave, is the period, therefore. The first maximum has place for $\lambda = 814.6\ \mu\mu$; the original λ therefore, is $814.6\ \mu\mu/1.185 = 6.87.3\ \mu\mu$; this is the tonic common to tastes and to odors.

It has been found that red rays filtered through a piece of cathedral glass produce a slight sensation of bitter upon the tongue. In the case of odors M. Henry has been able to distinguish with great precision six olfactory qualities or tones which he arranges in the order of the increasing λ as follows: alliaceous (i.e. partaking of the odor of garlic or onion), turpentine, musk, ether, benzol, balsam.

There are *vaporous tastes* and *liquid odors:* thus a saline solution in the nose gives a sensation of musk. The correspondence of these sensations results from the order in which M. Henry has arranged tastes and odors. Singular and striking as experiments of this sort may appear to be, they are, as we see, very useful in establishing a rational classification of sensations and their author deserves great credit for his ingenuity.

I asked M. Henry whether any immediate practical application of these researches were to be expected. He answered me in the affirmative, replying "Yes, I have discovered means of permanently modifying both the intensity and the breadth of certain radiations. I have thus been enabled to obtain perfumes which are far superior to ordinary ones both in intensity and in delicacy."

THE FRAGRANCE OF THE EARTH

ONE of the most agreeable fragrances which salutes the dweller on the country-side is the odor of the naked earth itself. This is especially noticeable in the spring of the year when the soil has just been turned up and the fresh, moist clods are exposed to the air. But it may be noted at any time of the year when the weather is not too cold or dry being especially marked just after a rain. The odor is peculiar and has been compared to that of newly fallen leaves, of sheep's wool, of rainwater, of lime kilns, etc.; yet it is entirely individual and quite unmistakable.

In the older works on agricultural chemistry this odor was ascribed to the slow decomposition of certain chemical compounds in the ground more or less difficult to define, and then contact with the mineral elements of the ground. According to some recent experiments by Rullmann, Salzmann, Jensen and Münter published in the *Schweizerischen* Chemikeizeitung this idea is incorrect. The odor in question proceeds from certain minute fungi of the soil belonging to the group of the so-called thread bacteria, and there are two species in particular which produce a marked odor. The proof of this is found in the fact that these bacteria can be isolated from the soil and made to grow in the laboratory on the most various mediums of *organic* instead of inorganic nature, such as pea-soup, the crumbs of bread, meat broth containing sugar, milk, glycerine, starch paste, etc.

On all these the bacteria developed their characteristic odor. It was even possible to isolate to a certain extent the chemical principle of the fragrance by a special process. In this way a liquid smelling strongly of fresh earth was obtained and when this was evaporated tiny crystals were left, whose composition could not be determined.

VEGETATIVE AND REPRODUCTIVE FUNCTIONS AND METABOLISM

THE fact that plants require or absorb mineral salts in varying ratios means that such absorption and utilization depend in considerable measure upon the composition of the plant itself, and will vary as such composition is varied. Changed or changing condition or expression is the external evidence of changed or changing composition. The living plant is constantly in a state of becoming adjusted to changing surroundings; it is the product of the interaction of all the elements of its environment. A change of any one of such elements requires a readjustment of the entire system unless such a change is at once offset by another which in its effects is antagonistic to it. If this is true, the necessity of possessing some facts or knowledge concerning the composition and the transformation of compounds in the plant in connection with those absorbed from the media surrounding it, is absolutely imperative. Anyone who has attempted such analyses can realize the difficulties to be encountered without being told about them. It is not sufficient to make determinations on whole plants *en masse;* the several parts must be considered separately in as minute detail as possible and then all must be related to the whole.

This is illustrated in the case of leaves and stems, when investigating the carbohydrate situation in a series of tests. Brief reflection will render obvious the fallacies of judgment which are likely to arise, especially when samples are collected during the day following a period of sunshine. The speed of digestion of the more complex carbohydrates (if any have been synthesized) and of their translocation is widely variable depending upon the other nutrients present. The presence of equal quantities of polysaccharides, indicated by analyses of material taken at any particular moment, in itself could by no means be interpreted as indicating an equivalent rate of synthesis, utilization, or storage of such products. These latter points could be determined only by a long series of analyses under varying conditions, or through indirect methods quantitatively measuring respiration, carbon fixation, and the like. Caution must be observed, also, in attempting interpretations of the analyses of plants already in any particular state or condition, the cause of which it might be desired to determine; it is only through the knowledge of a series of effects that causes can be deduced. For example, an analysis of fruit buds of any kind of fruit tree made during the winter or early spring will not furnish sufficient evidence on which to formulate a theory as to the nutrient relations necessary for their differentiation or presence. Instead, a number of observations from spring to winter are essential, for it is more than probable that the conditions determining meristematic differentiation are quite different from those accompanying the further development of the parts in question after initial differentiation, and the conditions for flowering may not be those for fruit setting and development.

The question may be asked, how is any knowledge of the relationship of vegetation and reproduction significant to practice? In reply it may be stated that it is at the very foundation of the whole matter of plant production, for on it rests the real understanding of such problems as cultivation, fertilization, irrigation, propagation, pruning (regeneration), phases of disease control, and many others. Certain points of attack become obvious at once to anyone really giving the problem thought. Even the working horticulturist is constantly contributing excellent experimental evidence, and is eager for some rational means by which he can interpret it.

In conclusion, then, it seems that the most needed essential to further extension of knowledge on the effects of varying metabolic conditions on the modification of vegetative and reproductive functions is the coordination of our knowledge of external and internal conditions. The working out and making available for study of the range effects of many more elements and compounds than the very few which are known at present is particularly desirable.—Abstract from article by Dr. E. J. Kraus in the *American Journal of Botany* for December, 1920.

Light and Chemical Energy*

Perrin's Brilliant New Theory with Regard to Effect of Wave Length Upon Reactions

By Professor Pierre Weiss, of the University of Strasbourg

In this address Professor Weiss has set forth lucidly and interestingly the main features of the very important and novel theory recently propounded by the distinguished physicist, Jean Perrin, to the effect that chemical energy is a direct result of the wave length of the various rays found in the visible and invisible spectrum. We omit the opening paragraphs of the address since they deal with such well-known properties of light as reflection, refraction, diffusion, etc., with which our readers are undoubtedly already familiar.—EDITOR.

LET us now consider the question of polarized light. As we know luminous vibrations are transverse instead of being longitudinal like those of sound. A metaphor will readily enable us to understand what is meant by the polarization of light. It is a simple matter to put a letter in the mail box if we present its edge parallel to the slit in the box, but if we present it in a perpendicular position to the slit it will not enter. The apparatus known as a polarizer may be compared to a letter box having a vertical slit. Let us now suppose a second slit in the letter box opposite the first. If these two slits are perpendicular to each other the letter will not pass through; if they are parallel it will pass. Correspondingly we may take a second polarizer and place it opposite the first in the path of a ray of light. To distinguish the two we call this second polarizer the analyzer, a word which expresses its function. The first apparatus is placed so as to allow vertical vibrations to pass. If the analyzer is arranged in the same way light will pass through the two without any difficulty, just as the letter passes through the two parallel slits in the box. But if we cause the second apparatus to revolve 90° around the ray of light as an axis of rotation, in this position it will allow only horizontal light to pass, and since the light coming from the polarizer is vertical no light will be able to pass.

Now let us make an experiment. By the rotation of the analyzer at a right angle we pass from full light to darkness, *i.e., extinction* and then by a new rotation, likewise of 90°, we pass from extinction to full light and so forth. It is obvious that this experiment can be comprehended only by supposing that light has a transverse vibration, since if light were moving in the same direction as the ray there would be no change.

Let us now interpose between the polarizer and the analyzer in the extinction position a sheet of a crystallized substance, e.g., a sheet of gypsum having an unequal thickness between one end and the other and obtained by the cleavage of a crystal of gypsum. Crystallized matter possesses the property of causing a profound disturbance in the direction of the vibrations of light which it receives. The vertical vibration falling upon it will be rendered partly horizontal, thus allowing light to pass. But since this effect is unequal in extent in the case of light rays of different colors, very vivid colors will frequently make their appearance. Thus we shall see certain areas of the gypsum appear upon the screen as red, others as green, and still others as yellow. Each thickness of the gypsum will give a different mixture of colors.

Now if we turn the analyzer at a right angle the light which passed in the previous experiment will be arrested and vice versa . . . so that in the second part of the experiment we shall obtain the colors which are the exact complement of those in the first, since the ensemble produced white light.

Instead of observing these two aspects of the light successively we can obtain them simultaneously side by side upon the screen, in which case we see clearly that a green area in one corresponds to a red area in the other and so on.

I have here several objects made from another crystalline substance — mica — such as the petals of a flower and the wings of a butterfly. These are formed of sheets of mica of different thicknesses; when we place them between the polarizer and analyzer we see the image of the butterfly or of the flower appear in colors upon the screen, and when we throw them upon the screen side by side at the same time we shall have a butterfly and a flower tinted in complementary colors.

The phenomena due to the transverse nature of vibrations and the possibility of separating these into different directions around the ray of light are very various in nature. Instead of obtaining the re-appearance of the light by placing between the polarizer and the analyzer a sheet of crystalline substance, we may arrive at an analogous result by using a parallelepiped of ordinary glass. We can accomplish this by imparting to the glass artificially optical properties which vary with the direction. This is done by exerting strong pressure upon the glass in which case the compressed glass acts like a crystal and the direction of the pressure exerted corresponds to one of the axes of this crystal. And we find that the stronger the pressure exerted upon the glass the more intense the light which reappears. And by studying this phenomenon mathematically we can even deduce the exact distribution of the internal tensions of which the substance is the seat. And it has been found possible to find an optical solution of delicate problems with respect to the resistance exhibited by various materials, by reproducing in glass pieces of metallic framework which are difficult to calculate, and then exerting upon the glass tensions or stresses identical with those to which the pieces of metal are subjected.[1]

These tensions are also encountered in tempered glasses, i.e., glasses which have been heated to a red glow and then cooled with sufficient abruptness to cause the surface to regain its rigidity first. We shall examine between the crossed analyzer and polarizer a series of such specimens of glass and we shall see that the very vivid play of colors observed gives a faithful image of the state of internal tension of the different areas.

Finally, we know that quartz crystals share with certain compounds of organic chemistry a certain property which has provided chemists with a key to the asymmetries of the molecule, namely; the power of rotation. But in the quartz this rotatory power which is manifested in full perfection only in the direction of the axis of the crystal, is a result of the crystalline structure. In the crystal of quartz the successive vibrations of the light are arranged like the steps of a winding staircase. If we interpose a plate cut from a crystal of quartz between the polarizer and the analyzer in the extinction position the rotation which it imparts to the vibrations will have the effect of producing a luminous movement which the analyzer will allow to pass. And since the rotation is unequal for the different parts of the spectrum the reestablished light will exhibit colors. Indeed, the colors due to the power of rotation are among the richest which we know how to produce. The artifice which we have already employed will give us a color and its complement at one and the same time and since it is

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[1]See "Determining Stresses by Polarized Light" by George Weed Hall and Arthur L. Kimball, Jr., in *Scientific American Monthly*, January, 1921, pp. 49-53.—EDITOR.

easy to superpose the two images we shall again see white light reconstituted by each couple of colored areas—blue and orange yellow, red and green, salmon and greenish blue.

If we observe the waves which traverse the surface of a sheet of water we perceive at once that there is a definite distance maintained between each two consecutive waves; this represents the length of the wave. With our crossed analyzer and polarizer we can perform one of the many experiments which enable us to determine the wave length of light. In the the rectangle of red light thrown upon the screen you observe a series of parallel bands which are alternately light and dark. We have divided the luminous movement into two portions. In the luminous band farthest to the right the two luminous movements arrive at the same time and reinforce each other. In the adjacent dark band one is half a wave-length behind the other, in consequence of which they counteract and destroy each other; a little farther in the second luminous band the retardation is twice as great, which gives us an entire wave and the movements once more added together, producing the full strength of light, then in the following band there is a retardation of 1½ wave lengths so that again the crest and trough of the waves meet and neutralize each other, and so on. . . By calculations based upon this phenomenon the wave length of the red light at the far end of the spectrum has been found to be eight ten thousandths of a millimeter.

Let us repeat this experiment performing it at the same time with red light and with green light, which we obtain by filtering white light through colored screens. Now let us place the two phenomena side by side—we observe that the red bands are farther apart than the green ones and perceive that the wave length of green light is shorter than that of red light. At the most highly refractive end of the spectrum the wave length is only four ten-thousandths of a millimeter. In the ultra-violet the length is still shorter while it is considerably longer in infra-red. The longest wave lengths of light which have been measured are one and one half tenths of a millimeter.

Let us suppose now that the temperature of a body is gradually raised. At a point slightly above 400°C. the rays emitted will begin to make an impression upon the retina of our eye and the body will appear dark red, passing later through cherry red and orange until it reaches an increasingly dazzling white . . . The proportion of the various rays alters and the higher the temperature becomes the richer the light is, both absolutely and relatively in violet and ultra-violet rays. If we reverse the experiment by cooling the body we gradually reach the red light and, finally, this becomes too feeble to impress the retina—beyond this point we have the infra-red rays whose wave length is the longest known.

Now let us imagine a closed metal box in which a vacuum has been produced and which is then heated from the outside. The internal walls will become incandescent as the temperature increases and will emit light which will traverse the box at the prodigious velocity at which light travels, i.e., 300,000 km. per second, until the light from one wall reaches the opposite wall where it will be reflected or absorbed. We perceive, therefore, that it is not precisely correct to say that this box contains *nothing;* as a matter of fact it contains radiations moving in every direction. And these radiations consist of a mixture of lights of all the colors and of all the wave lengths in proportions depending upon the temperature of the box at any given moment. If the temperature is lower than 500°C. there will be practically no visible rays present, but only infra-red rays.

Now the same process of reasoning holds true if we imagine the box instead of containing a vacuum to contain a solid liquid or gaseous transparent medium and if we cool it to the ordinary temperature of the air which surrounds us. In other words this very room in which we are assembled represents such a box. It is evident, therefore, that we are as a matter of fact, immersed in infra-red rays which come from every direction to strike and penetrate our bodies. All the work which we do, every operation we perform in our daily lives takes place in a bath of infra-red rays. When we consider this evident fact it seems curious enough that no one has ever thought of assigning to this agent a rôle of importance in the phenomena which surround us.

THE CHEMICAL ASPECT OF THIS PHENOMENA

Let us now examine the problem from a chemical point of view. Anyone familiar with chemical laboratories knows the important part played by heat in chemical processes. Whether he is concerned with one of the thousand operations of qualitative or quantitative analysis, whether he is dissolving a metal in an acid obtaining a precipitate or observing a color, the chemist nearly always heats the test tube in which the reaction takes place. A whole series of operations is conducted, by heating the bodies subjected to the experiment by means of a gas burner while they are traversing a tube.

Early chemists made much use of furnaces fed by wood charcoal; now-a-days, we have coke furnaces or electric furnaces . . . such as those, for example, with which Moissan made his brilliant discoveries . . . It is a well-known fact that a rise of temperature accelerates chemical reactions, whereas a fall of temperature retards them. At the temperature of liquid air reactions which are violent at ordinary temperatures—such, for example, as that of sulphuric acid upon potassium—are benumbed. But it is an accepted fact that heat is due to molecular motion and that chemical combinations and decompositions result from the violent shocks produced between molecules which come in contact with each other because of this motion. But there are some difficulites in the way of accepting this theory.

When there is a rise of temperature to 10°C. above the ordinary, the kinetic force of thermic agitation is augmented by a thirtieth and the velocity of the molecules by a fifteenth of their value. But there are a great many chemical reactions whose velocity increases much more rapidly—when it is even doubled, for example by a rise of ten degrees. It seems strange that there should be such a disproportion between cause and effect.

There is another difficulty which is perhaps even more serious. Let us suppose the case of a small quantity of the vapor of hydriodic acid (HI) in a closed container, say a liter. Let us now raise the temperature to such a point as to cause the vapor to break up into its component elements, hydrogen and iodine. This dissociation will take place at a certain rate of velocity.

Let us now put the same amount of vapor at the same temperature in a container holding 1000 liters. The molecules moving at the same velocity will have a thousand times as much space at their disposal and shocks of contact between them will be only 1/1000 as frequent. And yet we know by experience that the dissociation takes place with the same velocity. Therefore, it would seem impossible that the dissociation is produced by the shocks of contact between molecules due to thermic agitation.

But these difficulties and discrepancies vanish if we assume that the reactions are occasioned, not by the thermic agitation itself, but by the accompanying radiation. Thus no matter what the size of the container at the same temperature the molecules of hydriodic acid would be immersed in the same medium, consisting of infra-red radiations—and, if the temperature is high enough, of visible and ultra-violet radiations also—rushing through space in every direction. If we could accept this theory therefore there is nothing to surprise us in the fact that the velocity of dissociation is independent of the space occupied by the substance.

RELATION BETWEEN LENGTH OF WAVE AND CHEMICAL ACTION

We must believe with Perrin that every chemical reaction is produced by a radiation having a specific wave-length. If this be true it would suffice, in order to estimate the variation in velocity of the reaction due to temperature, to know the vari-

ation in the amount of this *active light* within the complex mixture of radiation. But it is a very remarkable fact that this calculation leads us to precisely that law which Arrhenius deduced from experiment some 30 years ago and which has hitherto remained inexplicable.

Inversely if we determine by experiment the velocity of the variation in a reaction due to temperature we can determine the wave-length of the ray of light which causes the reaction. For this purpose it is only necessary to choose among the complex mixture of rays of light of different wave-lengths that which has the same velocity of variation. Much study along this line will doubtless presently be undertaken—we will merely say now that in those cases in which such a calculation has thus far been made the wave-lengths obtained have been entirely plausible.

Let us now examine the same question from a different point of view. We know that colored substances merely select certain rays from white light and reflect them, while they absorb and destroy all the others. But there is one very important exception to this rule. Let us take a substance termed fluorescent, *e.g.*, a piece of glass containing certain amounts of salts of uranium incorporated with it. Expose this to a beam of light containing only the violet light which we obtain by passing a beam of white light through a colored filter. In this violet beam the uranium glass will shine brilliantly diffusing in every direction a vivid greenish yellow light. Thus we see that uranium glass is capable of transforming the original violet light into yellow light, *i.e.*, a light different both in color and in wave-length.

Organic chemistry provides numerous examples of fluorescent substances among which some of the best known are fluorescein, eosein, esculin, quinine sulphate, etc. The phenomenon is often intense enough to be perceptible even when the fluorescent substance is present only in an exceedingly dilute form or in extremely thin sheets. M. Ferrin placed under a microscope an extremely thin layer of a solution of these substances and exposed it to an exceptionally strong light by projecting upon it the image of the electric arc light. He was thus enabled to make an important and fruitful observation, namely: that the fluorescence of that part of the substance touched by the image of the arc light is extinguished at the end of a few minutes. If the preparation is so placed as to expose fresh portions of the substance to the light, these portions will become fluorescent and then be extinguished in their turn. It is evident, therefore, that fluorescence is not, as had been thought, a permanent quality of certain molecules, but is, on the contrary, the visible sign of their disappearance. The molecule struck by a certain radiation, by violet light, for example, dies as it projects a flash of green light and gives birth to a molecule of a different kind. The reason why the destruction of the substance at the moment it becomes fluorescent had hitherto been unperceived, is that until Perrin made his experiment investigators had always made use of too feeble an illumination and had employed such large quantities of the substance that the diminution of the latter could not be observed.

M. Perrin looks upon fluorescence as the typical case of all chemical reaction: a radiation is absorbed and occasions the reaction which gives rise to the emission of another radiation. The peculiarity of fluorescent substances consists in the fact that the radiation emitted and in many cases also the radiation absorbed are found in the visible spectrum. But when we remember that the invisible spectrum is far more extensive than the visible spectrum including both the infra red and the ultra-violet rays, there is nothing surprising in the idea that the eye fails to perceive any radiation in those reactions which are the most numerous and most ordinary of all. M. Perrin has gone a step further deducing by the doctrine of quanta (which there is no need of going into here) from a knowledge of the wave-lengths of the exciting light and the emitted light the amount of heat liberated in a given chemical reaction. The calculation made by him concerns the transformation of ozone into oxygen and the figures obtained were 62,000 calories, whereas 60,000 calories are obtained by direct observation. This is, very evidently, remarkably close agreement.

Let us take another experiment:

Let us expose to daylight some calcium sulphide containing traces of metallic impurities, and afterward examine this substance in a dark room. At first it shines with a comparatively bright light, but the intensity of the light diminishes by degrees. This is the phenomenon known as phosphorescence. The substance has absorbed certain rays of the light to which it has been exposed and later it yields these up. While this phenomenon is somewhat akin to fluorescence, it is distinguished from it by the fact that in reality it comprises two inverse reactions.

When the substance is exposed to sunlight some rays present in the incident light causes a chemical reaction of unknown nature and this reaction is accompanied by the emission of a certain infra-red ray. An exactly inverse reaction is involved necessarily in the re-emission of the absorbed light and the absorption of the emitted light. But in the mixture of infra-red rays in which all substances are immersed at ordinary temperatures, the substance will find the precise radiation which it emitted to begin with. This radiation will incite the inverse reaction and as a result, the incident light will be emitted.

This theory suggests a method of verification. If it be true that it is a certain infra-red ray which causes the emission of the stored up light, then it ought to be possible to increase the effect by increasing the intensity of this infra-red light. This can be done by exposing the phosphorescent substance to the infra-red spectrum of an incandescent body. As a matter of fact this experiment was actually made by E. Becquerel a good many years ago, but the results remained unexplained until it was found that they accord with Perrin's theory. When such exposure is made we first observe a more intense emission at those points where certain infra-red rays of a suitable wave-length fall upon the substance, but in these same areas the phosphorescence is more quickly extinguished so that they quickly become black, in contrast to those parts of the preparation which have not been exposed to the infra red ray.

Another manner of augmenting the intensity of the infra-red consists in raising the temperature. Behind a stream of calcium sulphide which has been previously exposed to sunlight we placed a rectangular plate of sheet iron heated to about 100° C. That area of the screen opposite the sheet iron becomes far brighter than the neighboring areas. But after a very short time their stored up light is exhausted and they become black.

The development of M. Perrin's theory promises to be of great value in science. If these new ideas are correct and it must be admitted that these primary verifications recited by us constitute a strong presumption in their favor, it is impossible to doubt that the knowledge thus gained of the actual mechanism concerned in chemical reaction must have a profound influence upon the development of both pure and applied chemical science.

We can readily imagine, indeed, a state of development of our chemical knowledge in some future day when, instead of making a crude use of the entire spectrum of radiations yielded by a given temperature, in which case certain ones of these rays produce the desired reaction, while others, on the contrary, produce the opposite reaction so as to partially cancel the effect, while still others produce what may be termed parasitic reactions—instead of this clumsy method let me repeat, we shall know how to make a definite choice of the precise ray required to produce the given effect. And let us make a solemn vow that in the future French science shall no longer be content merely with originating new theories and methods but shall determine to reap her fitting share of the harvest whose seeds she has sown.

Developing without a Dark-Room*

Phenosafranine as a Desensitizer of Ordinary, Orthocromatic and Panchromatic Plates

By Raymond E. Crowther

IN 1898 Mercier was granted a patent for a process of correcting over-exposure effects. The process comprised a bathing of the plate in dilute solutions of various substances, including several of the well-known developers, with subsequent drying.

This patent attracted the attention of Lüppo-Cramer, who made tests under varying conditions of the substances referred to, and in 1901 published his conclusion that the major effect of the patented process arose from desensitization of the emulsion by the solutions employed. He found that the specified substances desensitized to different degrees, but that generally with developers of the para-amino-phenol class the destruction of the original sensitiveness was of such an order that a plate bathed in a normally constituted developing solution could be exposed with impunity to a light which would fog a similar plate not bathed in developer.

Interest in the desensitization aspect of the matter was revived in 1907, when Lumière and Seyewetz confirmed Lüppo-Cramer's results, and made the observation that mere wetting of a plate with water considerably reduced its sensitiveness. Lüppo-Cramer immediately returned to the subject, and found that whereas only a very slight diminution of sensitiveness resulted from the wetting of a plate, the desensitization caused by immersion in certain developing solutions was quite marked with many types of emulsion, and, further, that the addition of sulphite to the developer powerfully inhibited the reduction in sensitiveness.

Continuing his work, and varying the developers and the methods of compounding their solutions, it was found that the greatest depression of sensitiveness was caused by dilute plain water solutions of amidol, triamino phenol, triamino benzol and triamino toluol in the form of their commercial salts —the hydrochlorides. Using a 0.05 per cent. solution of these compounds, for example, it was established that the sensitiveness fell, on bathing a plate for one minute, to one two-hundredth of its original value in the case of amidol, and as low as one six-hundredth of its original value in the case of triamino toluol hydrochloride. This led at once to a practical method of developing ultra-rapid non-color-sensitive plates in bright yellow light, all that was necessary being a preliminary bathing in the dark for one minute in a 1:2,000 solution of, say, triamino toluol hydro-chloride. Thereafter the plate may be lifted from the solution in bright yellow light and developed by inspection in a light sufficiently powerful to fog wet slow bromide paper rapidly.

But in these days of the more or less common employment of ortho', screened ortho', and panchromatic plates the matter could not be allowed to rest at this stage of incompleteness, and it became necessary to find a substance which would desensitize these varieties of plates and render their development by inspection a feasible proposition.

The happy spirit of co-operation which is the mark of scientific workers in every country placed at Lüppo-Cramer's disposal the range of products manufactured by the German dye-making firms, and knowing what type of substance was likely to be of service by reason of its chemical constitution, it was not long before the problem was solved. The final choice was made of the dye known as phenosafranine, and the effectiveness of this body is such that for the development of non-color sensitive plates in a yellow light bright enough to allow of the comfortable reading of newsprint at two yards' distance from the light, it is only necessary to replace one-tenth of the water used in making up one's favorite developer with an equal volume of a 1:2,000 solution of the dye, and screen the plate from the light during the first half minute or so in the developer. An easier method, and one which is applicable with complete success to panchromatic plates, is the following:

In the dark the plate is immersed in a 0.05 per cent. solution of the dye, and any time after one minute's immersion it may be removed therefrom in bright yellow light—or even by the light of a candle or oil lamp at a distance of 5 to 6 feet and developed by inspection. The plate may be lifted from the developing solution and inspected by transmitted light with impunity, a circumstance which indicates that the action of the dye is not simply that of a screen serving to cut off harmful light. As a matter of fact, one minute's immersion of a dry fixed out plate in the 0.05 per cent. solution of the dye stains the gelatine a bluish shade of red which, when examined by the spectroscope, is found to transmit the whole visible spectrum, only partially absorbing a short section at the junction of the blue and green. The worker who develops continuously will place his plates in the dye solution contained in a tank and remove them as he is ready for developing them, being unconcerned whether he is dealing with an ordinary, ortho', or panchromatic emulsion.

It may be objected that the dark-room is not entirely abolished and that the process offers no advantages over the method of bathing the plate in the dark before development with a dilute solution of potassium iodide, as recently recommended by F. F. Renwick, but a moment's consideration will convince one that the new process marks a real advance, for the immersion of the plate in the dye solution necessitates only a dark cupboard or recess, and can be undertaken by the least skilled hand in the workroom.

As far as comparison with the potassium iodide process is concerned, it is only necessary to recall that, in addition to the disturbance of the density obtainable, it is necessary to remove the potassium iodide by washing in the dark, to use special developing solutions, and a potassium cyanide fixing bath, and contrast these conditions with those of the pheno-safranine process, to rate the latter at its true value. In the new process there is no disturbance of the plate's characteristics; no washing after the one-minute immersion in the dye solution is called for; any developer may be used according to the particular fancy of the operator or the demands of the subject, and the usual hypo bath suffices for fixing. Further, the phenosafranine treatment considerably reduces the amount of chemical fog frequently encountered on pan-chromatic plates.

In one respect it is unfortunate that the most powerful desensitizer so far discovered happens to be a dye which, by virtue of its chemical constitution, tenaciously stains the gelatine. Somewhat prolonged washing in running water is necessary for its complete removal. This is not an uncompensated drawback, however, for one can be certain that when the film is washed free from dye it is also free from hypo. In cases where prolonged washing with water is inconvenient there are two methods available for hastening the operation. The first is to treat the developed, fixed and approximately hypo-free plate with a bath made by mixing equal volumes of a 2 per cent. alum solution and a 5 per cent. hydrochloric acid solution. The latter solution can be readily prepared by diluting one volume of the commercial acid with six volumes of water. The action of this bath depends upon the decomposition of the gelatine-dye complex by the acid, the strength of which is sufficient to act adversely on the gelatine unless the latter is protected—hence the use of the alum. Two or three two-minute changes of this bath allows of the removal of the dye by short subsequent washing. The second

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method of shortening the wash is the treatment of the hypo-free plate with a dilute solution of nitrous acid, whereby the dye is converted into a bluish violet compound which possesses but little affinity for the gelatine. The nitrous acid solution is conveniently prepared by dissolving five grains of sodium nitrite in two ounces of water and adding thereto ten minims of commercial hydrochloric acid. A four- or five-minutes' treatment with this bath should allow of a colorless film being obtained after five minutes' subsequent washing. In the writer's experience, the removal of the dye by simple water washing is preferable to either of the "short-cut" methods, and of these latter he prefers the acid alum treatment.

The dye with which Lüppo-Cramer carried out his research was the chemically pure product, and the writer has confirmed all his conclusions when using a sample of the same substance. This product in its pure form is not, however, an article of commerce, but the writer believes that a well-known firm of plate makers is about to place on the market a dye which exhibits all the desirable characteristics of pure phenosafranine.

Experimental Phonetics

Modern Methods of Studying the Production, Perception and Analysis of Sounds

By May Tevis

IN the widest sense of the word the science of phonetics embraces the whole domain of sound, including both noises and musical notes as well as articulate speech. In this wide sense it also involves a study of all the instruments, whether artificial or natural by which sound is produced and since sound can be perceived by us only through the medium of the ear, the past master of phonetics must understand the physiology of the auditory apparatus.

Such a past master in every branch of phonetics is the distinguished French savant, the Abbé Jean Rousselot. For this distinguished priest, who is now in his 75th year, a special Chair of Experimental Phonetics, has just been created under the auspices of the Bureau of Public Instruction, at the College de France, where he has been in charge of the laboratory of phonetics for something more than 20 years. Beginning with a small equipment and limited funds, M. Rousselot has, nevertheless, through his skill, ingenuity, and enthusiasm, succeeded in making his laboratory a marvel of completeness, so that no less than 18 others, the best equipped of which is that at Hamburg, have been modeled upon it. Much of the apparatus employed by him has been actually made by him and his pupils. The science of phonetics owes much to him, not only because of his inexhaustible passion for research, but because of his original inventions and of the improvements made by him in the apparatus devised by earlier students. Before describing some of this apparatus, let us cast a glance at the history of his life. Born in humble circumstances and apprenticed to a nail maker, he displayed so much talent for languages as to attract the attention of his teachers when hardly more than 13 years old. But it soon became evident that spoken language held far greater fascination for him than written words, and step by step he enlarged his field of research until it embraced the vast domains suggested above.

He soon found, for example, that he could not fully understand the most interesting and important branch of phonetics, that of human speech, without understanding the anatomy of all those various organs, a list of the more important of which we give elsewhere, which are concerned in human utterance. This, of course, opened up to him the further realm of acoustics, and through his studies of speech and hearing and through the instruments he devised for measuring and recording the changes in the lips, tongue, larynx, nostrils, etc., he has done much to assist the deaf to learn, to speak, and to read the speech of others by a study of the lips.

Finally, the most recent realm in which his knowledge and skill have been made to serve his fellow men is that dealing with the relation between sound and ballistics. During the war he spent many months at the front, erecting his delicate apparatus in the Forest of Fontainebleau. Here he and his assistants performed with marvellous accuracy the vital task of locating the batteries of the enemy. This was done by the analysis of the confused uproar of the battlefield into its component sounds, and recording the characteristics of these, so that with the aid of tables and charts it was possible to determine their origin and the distance of the source.

The term "vocal organ" includes all the organs used in speaking and singing. In order the better to understand the apparatus by which they and the sounds they make, can be studied in the laboratory it is best to remind the reader what these are:

The *trachea* is the outlet for the lungs. The rings of cartilage keep it distended. Behind it lies the oesophagus and the backbone. The trachea ends in the *larynx* which contains the vocal cords. In ordinary respiration the air passes through the trachea and larynx past the *epiglottis* into the *pharynx* through the *nasal cavity* and out the *nostril* on each side.

The *nasal cavity* on each side is of very complicated form owing to the various processes projecting into it. The *oral cavity* is roofed by the *hard palate* and the *velum* or soft palate. The *pharyngeal cavity* may be divided by closure of the velum across it into two parts, the upper or nasal portion and the lower or oral portion. In this case the entire mouth cavity from the lips to larynx is made up of the oral portion and the pharyngeal portion. The fall of the velum turns the pharynx into a single cavity and separates it more or less from the oral cavity.

The muscles controlling the movement of the lower jaw are: 1. the *temporal*, which raises it, and, if it has been projected, draws it back; 2, the *masseter* which raises it; 3, the *internal pterygoidal*, which raises it and may give it slight side movement; 4, the *external pterygoidal*, which projects it or twists it to one side. The last two muscles are attached to the back part of the jaw.

The *orbicularis oris* consists of a muscle layer formed of fibers radiating from the corners of the mouth into the upper and lower lips, some of the fibers running around the corners. When the fibers of the upper and lower lips act together, they constrict the mouth. Physiologically each of these muscles is considered to be divided into an outer zone and an inner zone. When the outer zone alone is contracted the lips are compressed and thrust forward, while when the inner zone alone is contracted the lips are pressed back against the teeth. Moreover, each lateral half of each muscle is able to act independently. We cannot here describe all the various muscles which are brought into operation. Enough has been said to show the great complexity and delicacy of the apparatus which has been developed by man in the course of untold ages, not only for the production of sound, but for its modification in literally thousands of ways to form the words and cries by which he expresses his emotions and thoughts and holds intercourse with his fellow creatures in a multitude of languages.

Some of the apparatus invented or perfected by the Abbé Rousselot has had for its special object the recording, with minute precision, of the infinite variety of motion in the lips, the tongue, the nostrils, and other organs, by means of which vowels, consonants, musical notes, and words are formed and modified. As an example of the minute attention devoted by Rousselot to every phase of the subject we may mention the fact that after two months of careful phonetic observation, he perceived for the first time the differences between the speech of his

M. L'ABBÉ ROUSSELOT AND HIS APPARATUS FOR RECORDING SPEED

mother and that of himself, and noted that a regular progression in change of dialect could be observed in the speech of three generations of the same family; he also found that there were stages of phonetic change even from village to village, which throws an interesting light upon the development of dialect.

He has in fact, made an extremely comprehensive study of French dialects, and particularly of that of Paris, to which he has devoted a special volume.

THE PHONETICS IN SPEECH

Sounds differ from each other in three factors, pitch, intensity or loudness, and quality. The most important of these, so far as speech is concerned is the quality. In articulate speech sounds are divided into two broad classes—vowel sounds, which can be held for a considerable length of time, and consonantal sounds, which consist essentially of a peculiar stopping or starting of a vowel sound, and which often are employed in forming a transition from one vowel sound to another.

It is a curious fact that just as the intensity of a sound decreases with the distance of the hearer from its point of origin, so does the barely perceptible difference in speech sounds change at different distances. Studies by Wolf of various sounds in the German tongue show the vowel *a* is capable of being heard at the greatest distance, and this distance decreases gradually in the following order, *o, ai, e, i, au, u, sh, m, n, s, f, k, t, r, b, h.* In some similar experiments Rousselot found that no sound was distinct when spoken in the usual tone of voice at a distance of 9.6 meters, but that when this distance was diminished to 9 meters the ear understood *a, e, i, o,* and *y, p, k, t,* at 8.55 meters; *b, sh,* sometimes *s,* rarely *f* at 7.10 m.; *s* and *f* very distinctly *at* 7 m.; *d, m, n,* at 6 m.; *zh, g,* at 5.7 m.; *zh,* at 5.5 m.; *v. u, œ* at 5 m.

Professor E. W. Scripture, one of our leading authorities in America upon phonetics, terms this property of speech sounds *acoustic penetration* and he suggests that analogous experiments to these of Wolf and Rousselot might enable us to make a systematic investigation of the penetrative power of the various sounds in any given language in a given speaker or singer of given conditions of mind or body and of given methods of speaking.

Rousselot's Vocal Tambour.—One of Rousselot's inventions is known as a vocal tambour. It consists of a bent metal tube one end of which is covered with a rubber membrane, which moves a very light stylus. A mouthpiece is fitted into the other end of the tube and the vibrations of the membrane produced by the sounds of the voice in front of the mouthpiece are recorded by a lever which is made adjustable by a screw. This tambour is admirably adapted to recording small variations of pressure, such as are found in various speech sounds like *r*, the explosives, etc.

The methods used for studying muscular movement include, among others, that of air transmission by Marey tambours.

The tambour is a metallic box with a rubber top and a side tube.

Artificial Palates.—The contact of the tongue with the palate is studied by a thin shell-like artificial palate which is covered with chalk and then placed in the mouth. The impressions made upon it by the tongue are known as palatograms. Rousselot has published plates showing dozens of these. It seems probable, however, that even the thinnest plate somewhat modifies the record.

The Phonograph.—Though of great service in the study of speech sounds the phonograph is too well known to be described here.

TUNING FORKS

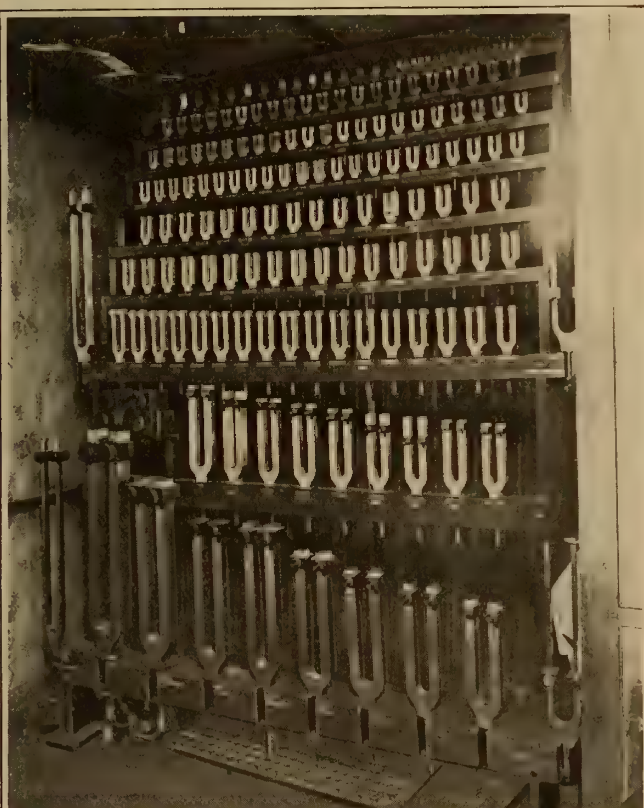
One of the simplest instruments for determining pitch is the tuning fork. This instrument consists of a resonant bar of metal bent into the shape of the letter U, and provided with a handle at the bottom of the U. When struck it vibrates so as to produce a musical note and this note varies in pitch according to the size and the weight of the fork. Tuning forks like other vibrant bodies have the quality of resonance. When a vibrating tuning fork producing a note of a certain pitch is brought near a collection of other tuning forks of different sizes and consequently of carying pitch, those which are attuned to the pitch of the vibrating fork will pick up the note of the latter and vibrate in harmony with it. This at once indicates a method by means of which a collection of tuning forks can be made to analyze the various elements in a complex sound. Such a collection or "battery" of tuning forks is shown in one of our pictures. Here the huge fork in the lower left hand corner vibrates only 32 times and, therefore, produces a very low and barely audible tone. At the upper right of

the picture is seen the smallest tuning fork, whose high, thin, piercing note is due to its great velocity of vibration, which is 40,000 per second. Between these limits is a tremendous variety embracing practically every discernible pitch, *i.e.*, rate of vibration.

Tuning forks are among the most important of acoustical instruments; they were invented in 1711 by John Shore, Handel's trumpeter. The fork reached an almost perfect development under the "exquisite workmanship and painstaking research" of Rudolph Koenig of Paris. When properly constructed and mounted it gives tones of great purity and constancy of pitch; it is of very great value in experimental work and provides the almost universal method of indicating and preserving standard pitches for all purposes.

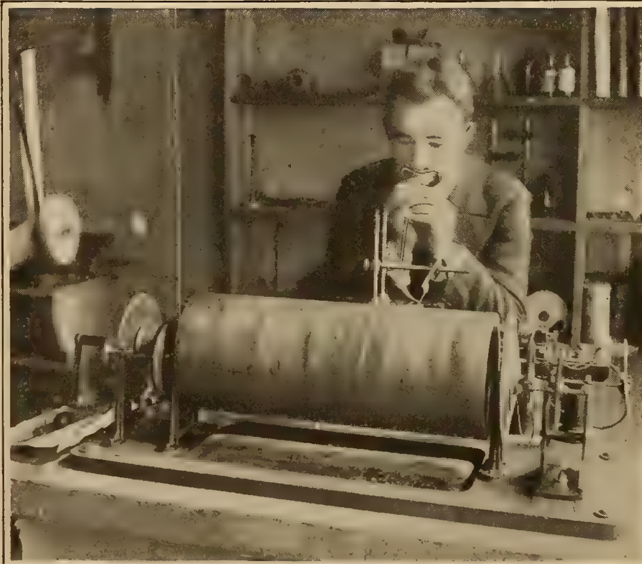
A tuning fork for scientific purposes should be made of one piece of cast steel, not hardened; the shapes developed by Koenig have not been excelled according to our foremost authorities.

The number of vibrations of a fork is dependent upon the mass of the prongs and the elastic force is due principally to the yoke; if the prongs are made lighter, by filing on the ends or sides, the pitch is raised; if the fork is filed near the yoke, the elastic restoring force is diminished and the pitch is lowered. A fork which has a yoke which is very thick in proportion to the prongs, is suitable for high pitches. Experts advise that a standard fork having been accurately machined and finished, should be left with the prongs a trifle too long, that is, flat in pitch; the final tuning should be carried out very carefully by shortening both prongs together till the desired frequency is secured. Filing or grinding a fork will heat it, as will also the touch of the fingers; the heating lowers the pitch of the fork, and if it is tuned while thus heated, it will later be found too sharp, that is, the prongs are already too short. Therefore the filing should stop while the fork is yet two or



A BANK OF TUNING FORKS GIVING PURE TONES RANGING FROM 16 TO 40,000 VIBRATIONS PER SECOND

three tenths of a vibration flat, and the fork should be allowed to remain at a uniform temperature for a day or two before a comparison is made; if further tuning is necessary, it must be done with extreme care, and a comparison again made after another interval of rest. Vigorous filing will produce molecular disturbances which it takes a long time to correct. The boxes on which the forks are mounted act as resinous chambers; the box serves a double purpose in fact: It causes the



A DELICATE SPEECH RECORDING INSTRUMENT

sound to be louder and it also makes the tone clearer, since it reinforces only the fundamental note. Koenig proved that the number of vibrations of a tuning fork is altered by a change of temperature, the temperature coefficient being nearly constant for forks of all pitches, and having the value 0.00011. The change in the number of vibrations is found by multiplying the frequency by this co-efficient and by the number of degrees indicating the change in temperature. The negative sign indicates that the frequency is diminished by a rise in temperature, thus, a fork vibrating 435 times per second at 15 deg. cent. will have its frequency diminished by 0.48 vibrations when the temperature rises 10 degrees.

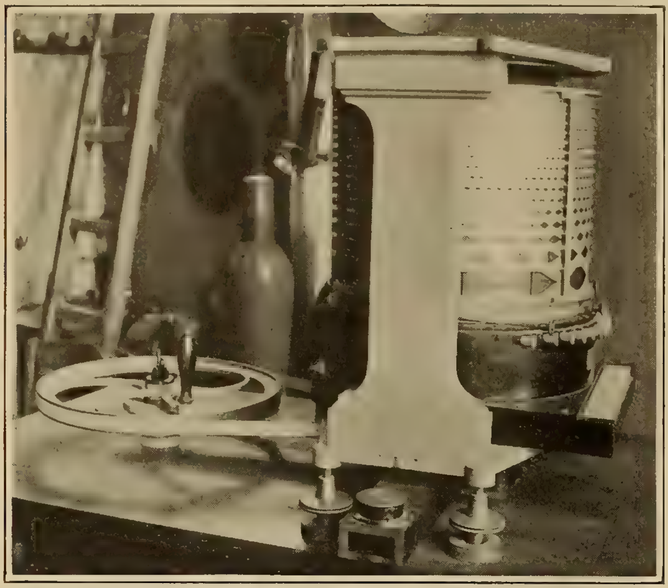
Tuning forks are made to vibrate in various ways. When a very loud sound is desired the bow of a violin may be drawn across the end of one prong. In laboratory experiments it is usual to strike the fork with a soft hammer such as a felt piano hammer head with a flexible handle. Sometimes a rubber ball or a rubber stopper is used, while for a thick, high pitched fork, says D. C. Miller in his recent work, *The Science of Musical Sounds*, an ivory hammer is best. This authority warns experimenters never to strike tuning forks with metal or other hard objects, since being of soft steel they can thus readily be injured.

Sometimes forks are made to give out a continuous sound by means of an electro-magnetic driving arrangement. A fork may be driven by its own vibrations, since when these are once started they produce the necessary interrupted current. Sometimes a fork or a series of forks is driven by an alternating current from another source, such as an outside interruptor fork used to drive a series of ten forks. In the latter case the periods of the forks must be exact multiples of the period of interruptor, since a fork will respond only to impulses in accord with its own natural vibrations.

COMPOSITE TONES PRODUCED BY TUNING FORKS

An extremely interesting experiment to demonstrate the quality of composite tones is described by Dayton C. Miller, the well-known professor of physics at the Case School of Applied Science in Cleveland. To perform the experiment a set of ten forks is arranged in line, each being exactly tuned to the pitches of a fundamental tone having the deep, low note produced by 128 vibrations per second, and the 9 harmonic overtones. Mr. Miller says: "When the fundamental alone is sounding a sweet but dull tone is heard. As the successive overtones are added the tone grows in richness, until the ten

forks are sounding, when the effect is that of one splendid musical tone. One is hardly conscious that the sound is from 10 separate sources, the components blend so perfectly into one sound. The tone is vigorous and 'living' and has a fullness



ROUSSELOT'S IMPROVED FORM OF KOENIG'S WAVE SIREN

and richness rarely heard in musical instruments . . . If, while the forks in the above experiment are sounding, they are silenced in succession from the highest downwards, the tone becomes less and less rich, until finally the fundamental alone is heard. This is a simple tone and is of a dull droning quality; the experiment demonstrates that a *pure tone* is a *poor tone.*

This experiment demonstrates one method in which experimenters can utilize tuning forks to analyze sounds into the fundamental and the overtones which compose them.

The expenditure of breath when vocal sounds are made is very variable, but experiment has shown that in ordinary speech there are certain constant relations. The tambour records made by Rousselot show that the breath expenditure differs at different times of day and also with different activities, as well as with the position of the body, *i.e.*, standing, sitting, or reclining.

STUDYING THE HUMAN VOCAL APPARATUS

Records of the action of the larynx generally refer either to its rise and fall or to the pitch of the tone it produces. The former can be registered by tambours with special projecting arms. The larynx is higher for *a* than for *u*, and lower than for *i*. For *e* it is somewhat lower than for *i* and for *o* somewhat higher than for *u*.

In studying the action of the larynx Rousselot has used a carbon microphone to interrupt an electric current in accordance with the movements of air which accompany the spoken sounds. Instead of a telephone diaphragm the variations in the magnet comprised in the circuit were transmitted to an armature held by a membrane of varnished parchment whose movements were registered by a recording arm. The delicacy of some of these experiments is shown by Rousselot's demonstration that when a German utters the sounds *pa* and *ba* the larynx does not begin to vibrate until much later than when a Frenchman utters them.

Rousselot has also employed a tongue tambour to study the movements of the tongue which assists in the modification of speech. It is also possible nowadays to study the tongue while in action by means of X rays.

The movements of the lips may be registered by a pair of light arms attached to a Marey tambour; an open tube may be placed before the lips to register the breath pressure, and in Rousselot's experiments each lever was made to register separately. The pressure of the lips may also be measured by a small rubber bulb placed between them. Such bulbs are sometimes called exploratory bulbs. They are of various sizes and shapes, being sometimes placed in the nose, sometimes in the mouth, sometimes between the lips, and sometimes in the ear to test the movement of the jaw. Those invented by Rousselot to measure the air pressure in the nostrils are called nasal olives.

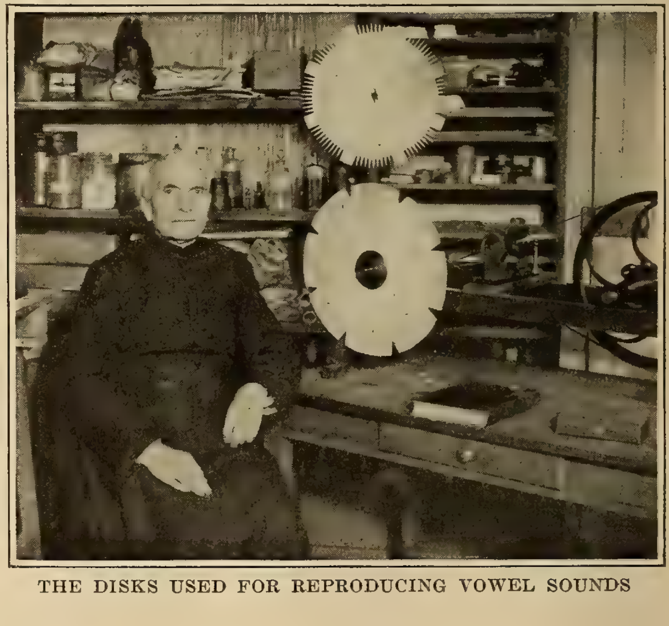
Some of Rousselot's practical applications of his studies have had to do with teaching the deaf to speak—the auditory motor associations being capable, in many cases, of being replaced by visual-motor associations. He has also used the same method for improving the pronunciation of foreigners.

THE SIREN

One of the most valuable instruments for studying sound is the siren. In its simplest form this consists of a metal disk pierced by a circle of holes at regular intervals and carefully balanced and trued. When a jet of air is sent against such a disk while it is in rotation, a series of puffs of air is produced. When the disk goes very slowly these puffs can be perceived separately, but as the speed increases the puffs merge into each other and produce a tone; this tone is at first very deep and dull, but as the velocity of the disk, which is generally mounted directly on the axle of a small electric motor, increases, this tone gradually rises in pitch until it reaches a point beyond which the human ear can no longer perceive it as sound, though it is quite conceivable that certain creatures such as some insects, for example, may have their auditory apparatus attuned to the perception of still more rapid vibration. The rate of the electric motor is regulated by an appropriate resistance, such as a lamp resistance for great changes in speed, and an adjustable wire resistance for smaller changes.

The property of duration in a tone can be illustrated by changing the time during which the tone is produced; the property of intensity by making it louder or weaker.

The pitch of the tone from the siren at any moment can be determined by placing on the axle of the motor a contact consisting of a gear wheel with spaces filled by vulcanized rubber, and adjusting a pair of copper brushes on its rim. A battery current is sent through the brushes, a make-key and a magnetic marker whenever the knob is pressed and each closure will register a check in the line of the marker-point on the drum. To get a registration of the time the marker is connected to a fork in such a way that the breaking of the circuit sets it



THE DISKS USED FOR REPRODUCING VOWEL SOUNDS

vibrating. This can be conveniently done by using the key as a shunt around the marker in a circuit coming from the fork. A comparison of the checks in the line from the marker with the waves of known frequency from the marker will give the

time between contacts at the brushes; from this the speed of the disc and the number of puffs can be readily calculated.

An apparatus known as a "wave" siren was devised by Koenig for producing any desired wave motion. This he did by cutting the shape of the wave on the edge of a disk. He also made a large wave siren for compounding sixteen simple tones of various loudness and phase. Our picture shows an adaptation and improvement of Koenig's siren made by Rousselot.

MAKING SOUND WAVES VISIBLE

The most interesting feature of sound is the quality of its tone and a study of this requires us to consider the form of the wave which produces it. Physicists have sought, therefore, by various methods to obtain visible records of sound. Most of these make use of a sensitive diaphragm to receive the wave motion. A diaphragm is a thin sheet or plate of elastic material, generally circular and supported more or less firmly at its outer edge. Thus in the telephone the vibrating diaphragm is made of thin sheet iron; in the phonograph sheets of mica are often used, and in a piano the sounding board is merely a wooden diaphragm. In laboratory experiments many other materials are employed, such as paper, parchment, rubber, a film of soap suds, metal, glass, gelatine, etc.

As we daily prove when we talk into a telephone with a good connection or listen to a phonograph, diaphragms are remarkably sensitive to an immense variety of combinations of tones covering a very wide range of pitch.

The Phonautograph.—In 1859, the Scott-Koenig phonautograph for directly recording sound waves was perfected. It consists of a membrane placed at the focus of a parabolic receiver or sound reflector; to this membrane a stylus is attached and in front of the stylus is a drum carrying a roll of smoked paper. Any sound produced in front of the receiver causes the membrane to vibrate in harmony with its wave motion, and these vibrations are recorded upon the smoked paper. A tuning fork is mounted on the base of the instrument in such a manner that its prongs are between the membrane and the paper. A stylus attached to one prong of the fork marks a simple wave line by the side of the tracing made by the membrane. In this manner Koenig obtained a number of comparative records, in which the tracing made by the tuning fork lies directly above that made by other instruments, such as voices, combinations of organ pipes, etc. But these records are very small and are apt to be distorted or even obliterated by friction and by the momentum of the recording point.

The Manometric Flame.—Three years later Koenig made a brilliant invention which has been much used ever since in the form of a "manometric capsule," in which the flame of a gas jet vibrates in response to the variations of pressure produced by a sound wave. Still later Professors Nichols and Merritt suggested the use of acetylene gas, thus making it possible to photograph the flame. Some very beautiful illustrations of wave motion are obtained in this manner and these records can be filed and compared with others whenever necessary.

Motion Pictures Shown in Relief

The Glypho-Cinematograph for Producing Stereoscopic Effects

A FRENCH physician, Dr. J. L. Pech, connected with the Faculty of Medicine at the University of Montpellier has recently propounded a novel theory with regard to the reason why under certain circumstances the eye obtains three-dimensional effects. It has long been held by men of science that binocular vision, *i.e.*, vision in which the two eyes focus together is the principal reason for our perception of objects in relief? This hypothesis has failed to satisfy Dr. Pech for four reasons, which may be stated as follows:

I. Looking at pictures through a stereoscope rapidly induces fatigue and headache, thus indicating that there is somthing physiologically abnormal about this method of obtaining impressions in relief.

II. Stereoscopic relief differs from that perceived by the unaided eye; the latter sees objects in their primary planes in alto-rilievo, *i.e.*, in the round followed by successive planes and not as a series of silhouettes without thickness, clearly defined against a background formed of a single plane, as is the case in the vision of stereoscopic images.

III. The study of the phenomenon described by Helmholtz under the name of "antagonism of visual fields" leads us to believe that the total perception of two visual fields which is required for vision through a stereoscope, is not a normal physiological phenomenon.

IV. Many persons who have been blind in one eye from birth have no difficulty in perceiving perfectly the objects they look at in relief, just as do normal persons.

These considerations induced Dr. Pech to make a study of the subject which led to some interesting results. To begin with he found in the course of his researches that there are a number of methods by means of which a single eye may become capable of receiving an impression in relief. Writing in *La Nature* (Paris) for January 29, 1921, he describes some of his experiments along this line.

He found first that an ordinary photograph produces this sensation of relief on being examined by one eye when it occupies the entire visual field, because of being placed farther from the eye than the nearest point at which distinct vision is obtained.

Again it produces this effect when seen by reflection in a concave mirror having a focus of about 1 meter, especially when the mirror is parabolic in form.

Thirdly, the same result is obtained when the photograph is examined through a powerful double convex or plano-convex lens whose spherical aberrations have not been corrected.

In all these cases, says Dr. Pech, the sensation of relief is exactly like that obtained by ordinary eyesight instead of being exaggerated as in a stereoscope.

These interesting observations led Dr. Pech to form the following conclusions:

I. An ordinary checker board marked off into squares by straight lines, produces upon the retina, when it occupies the entire visual field (thus causing a relaxation of the function of accommodation), an image having curved lines instead of straight lines, as shown in the diagram of Fig. 1. This is a well known fact long ago observed by such prominent men of science as Helmholtz, Tscherning, etc.

II. Since a plane photograph is seen with a marginal distortion, either because it occupies the whole of the visual field, or because it is seen as reflected or refracted by such a mirror or lens as is described above, it seems reasonable to suppose that these marginal distortions may be an important factor, hitherto unrecognized, in producing the impression of depth, commonly called relief. Dr. Pech next proceeded to test the correctness of this ingenious theory by means of actual experiment. He first endeavored to obtain a distorted image, which, being large enough to be seen at a distance of 6 or 7 meters, would cease to exhibit distortion and furnish the sensation of relief. But in practice it is not possible to obtain photographic images exhibiting similar distortions by means of uncorrected lenses. It is necessary, therefore, in order to obtain an image which shall be clearly defined at all points to have a sensitive plate possessing a curved form similar to that of the back of the ball, so as to coincide with the focal

surface of the lens. The inventor's next step, consequently, was to prepare by means of preliminary calculation screens of such curvature that a photographic image projected upon them would make upon the eye of the spectator the same impression as is made by the real objects themselves upon the naked eye, when so placed as to cover the entire visual field of the observer.

These screens, to which the name of glyphographs (from the Greek words *glyph*=engraving, and *graph*=inscription) has been given, are formed by stretching a sheet upon a frame whose edges are hyperbolic in a plane which is perpendicular to the surface of the screen, as indicated in the diagram shown in Fig. 2. By means of a rather complex formula, the inventor succeeded in calculating the perimeters of the hyperbolas in proportion to the dimensions of the screen.

These glyphographs of Dr. Pech have already come into

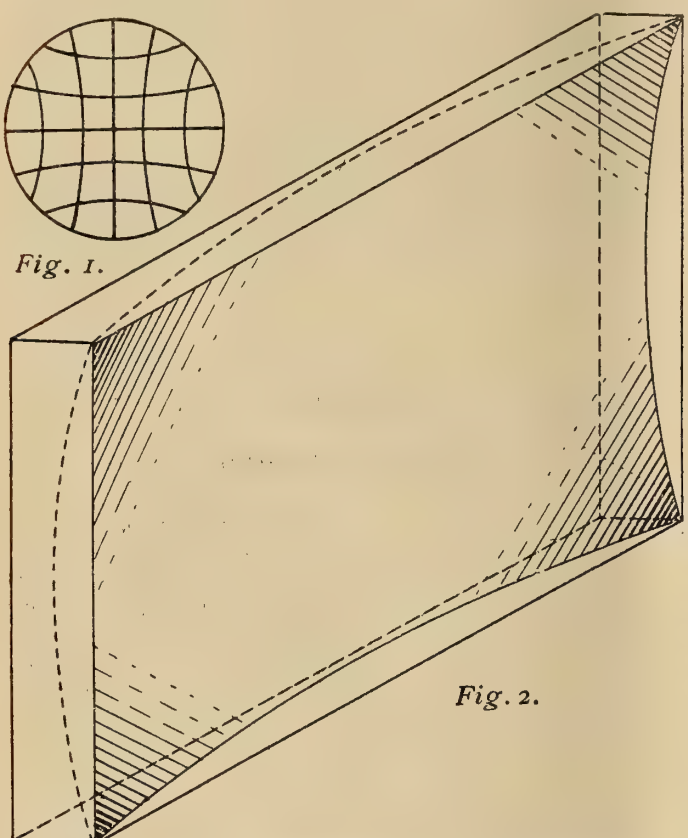


FIG. 1. IMAGE OF A CHECKER-BOARD UPON THE RETINA. FIG. 2. THE GLYPHOGRAPH SCREEN

fairly extensive use both in this country and abroad, and according to experienced cinematographers possess the following advantages:

I. The images projected upon these screens give a true impression of depth without any apparent distortion.

II. The images are clearly defined at all points and have a uniform illumination because of the fact that the screen occupies approximately the location of the focal surface of the projecting lens.

III. Even when seen from positions very close to the screen and greatly to one side the images are not unpleasantly deformed as is the case when a plane screen is employed.

IV. Moving pictures are much less fatiguing to the eye of the spectator when seen upon such a screen.

Dr. Pech admits that many other investigators in various countries have previously patented screens of spherical, cylindrical, or prismatic form, but he claims that none of these has produced satisfactory results, since in none of them were the preliminary calculations correct, as in all cases they failed to take account of the essential factor involved in the peculiarities of the human retina. In other words the superiority of the Pech screen consists in the fact that it is not only based upon calculations respecting the focal surface of the projecting lens, but takes into account also those distortions of the image formed upon the retina which are due to peculiarities of the refractive lenses contained in the human eye.

THE OPTICAL INDUSTRY

FROM time to time notice has appeared in the press relative to the importance of our optical industry and that this is not confined to the United States is evident from an article in *Nature*, February 10, concerning the promotion of the British optical industry. The British Government has promised to introduce in the House of Commons at the next session a bill to safeguard and foster certain key industries and of these optical glass and optical instruments are to be given special consideration. Industries of this type because they are relatively small, not employing large amounts of capital nor great numbers of employees, are likely to be overlooked. It is, of course, dangerous for any nation to estimate the value of a particular industry by the amount of capital invested or the number of people employed.

In Great Britain, as elsewhere, the scientific industries are exposed to most skilful German competition which is now more of a menace than ever due to the rate of exchange. It is unusual to have a British industry consider protection essential to its life, but the optical glass and instrument industries through their association now ask that the following measures of protection be provided:

(1) No optical glass or scientific instruments to be imported to the country for a period of seven years except under license.

(2) Such licenses only to be granted in respect of goods which are not being made in Great Britain in the required quantities or of the required quality.

(3) An expert licensing committee to be set up.

(4) The optical instrument manufacturers are prepared in order to guarantee reasonable prices to submit to a control of profits.

That the manufacturers are taking due measures to promote scientific research and improve their product is guaranteed by the fact that a scientific instrument research association has been formed by the leading manufacturers as an educational activity to their research already carried on in their own establishment.

IMPROVEMENTS IN DYEING

IN discussing the work of the dyer and cleaner before the Rochester Section of the American Chemical Society, Mr. E. B. Leary recently pointed out that the old method of matching certain colors in order to duplicate an order was to dye several samples of yarn at the same time the fabric was being dyed. But this method is rapidly becoming displaced by the use of a new type of colorimeter. With the aid of this instrument the shade and hue of the color to be matched are determined and recorded according to a series of arbitrary numbers which correspond to the numbers of standard color filters and wedges used with an ordinary daylight lamp. By the use of such an instrument the merchant may order fabrics to be dyed in accordance with numbers stated by him, thus eliminating the former dependence upon the measure of the shade by the use of fanciful trade names which are too inaccurate to serve as a guide for dyeing.

Mr. Leary also pointed out that, whereas in the past the dyeing has been in the hands of craftsmen who were without scientific training and who learned their trade by apprenticeship with all its many secrets, today the dyer is technically trained and capable of using the many delicate scientific instruments being developed for his assistance.

Incidentally, it is interesting to note that two decades ago the quantity of dye required to dye a woman's dress was about four times that required today. This is largely due to a change in style including the weight of the fabric.

PREPARING THE ORIENT ESSENCE IN THE LABORATORY OF AN AMERICAN ARTIFICIAL PEARL FACTORY

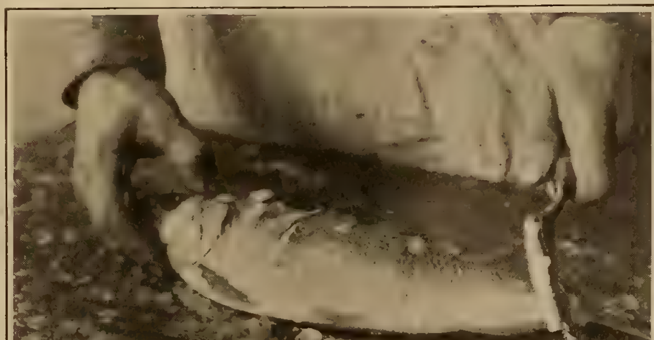
Artificial Pearls

"Orient Essence" of American Manufacture

By T. A. Marchmay

IMITATION is the sincerest form of praise and by that token there is perhaps no natural product so much admired by man in every age and among every race, savage or civilized, as the pearl, the queen of gems, surpassing even the diamond in its appeal. The supply of pearls formed naturally has never sufficed to meet the demand. Pliny speaks of the trade in pearls, "the most precious commodity of the world." But it was doubtless before Pliny's time that the Chinese, the discoverers of so much that has since been rediscovered in the Occident, endeavored to make two pearls grow where one grew before by introducing bits of gravel, etc., —even on occasion tiny images of Buddha—into the shell of the oyster in order that the animal might be forced to protect its tender tissues from irritation by covering the foreign body with a coating of nacre. Certain natives of the South Seas have an even similar method, so they believe, of producing pearls artificially. To these simple souls the pearl is a sentient thing, with a personality of its own, and those powers of reproduction which other sentient beings have. In pursuance of this theory, and regarding seed pearls as the offspring of larger pearls, it is their custom to select two fine specimens and place them together in a closed vessel, together with a few grains of rice, and it is their solemn belief that if all goes well, when the vessel is opened a few months later, it will contain not only the original pair but a number of seed pearls, the offspring of the former, while the rice will be found to have its edges nibbled! This same superstition holds sway in Borneo, but in that island the conditions of this singular experiment in breeding are rather more difficult to carry out. Pearl divers regularly put aside every ninth pearl of suitable size, placing the collection in a bottle, but it is an absolute *sine qua non* that the neck of the bottle be stopped with a dead man's finger, and Mr. George Kunz tells us that in a certain locality all the graveyards for miles around have been robbed with this ghoulish design! Strictly speaking, however, imitation pearls such as the images of Buddha described above are rather *artificially bred* pearls than artificial pearls proper. The latter are fashioned by the hand of man, of various substances, including wood, wax, stone, plaster, glass, etc., and then coated, in most cases at least, with a special pigment to give them the appearance of true Orient pearls.

The pigment *par excellence* which produces this effect—the soft luster of the moon livened by the delicate colors of the dawn—is the Essence d'Orient, also known as Orient Essence and as Pearl Essence. For the discovery of this natural pigment we are also indebted to the Chinese. The first artificial pearls to which pigment was applied in Europe were made in France and consisted of small balls of plaster, covered with a paste prepared from the scales of the white fish or bleak mixed with glue. The pearls made in this manner were very handsome indeed while they reposed in the jeweler's box, but when they were worn by the fair recipient, the heat and moisture of her body, alas! caused the glue to melt so that the silvery color ran off, leaving the necklace to look like fragments of a ruined fresco.



SCRAPING THE SCALES OFF A SEA HERRING

But in 1680 an ingenious French maker of rosaries at Paris, named Jacquin, conceived the idea of making the body of the false pearl of glass. The process he employed is practically that

which is in use today, with certain modern improvements, of course, but essentially the same in principle, *i.e.*, a coating of thin hollow globes of glass with a paste made from iridescent fish scales.

One of the modern improvements is the imparting of an opalescent tint to the glass employed by means of a careful treatment with hydrofluoric acid.

A GROUP OF GIRLS FORMING THE GLASS BEADS WHICH FORM THE BASE OF THE ARTIFICIAL PEARL

THE MAKING OF ORIENT ESSENCE

As stated before in this article, the pearly sheen and the delicate play of color found in real pearls of fine orient, are imparted to their false but fair *simulacra* by means of a preparation made from the scales of certain fish and called in French Essence d'Orient and in the American trade Orient Essence, or Pearl Essence. Not all fish scales are equally suitable for the preparation of this product. Hitherto, it is the scales of the small white fish, known as the bleak, very generally found in the stream of Europe, which have been found best suited for this purpose. In both Germany and Italy these fish have been caught on a very large scale merely with the object of making this essence. The writer has been told rcently, however, that the finest material was imported to France from Russia. The Russian débâcle has naturally played havoc with this supply as with so many other valuable Russian exports, consequently, not only French manufacturers of fine artificial pearls have found their supplies cut short, but American manufacturers were in despair of getting any at all. As a consequence they besought the aid of the government to find an American substitute. The happy result of the researches undertaken at their request, under the auspices of the Bureau of Fisheries, has been the notable discovery that the scales of the shad and of the sea herring are capable of furnishing as choice a product as those of the bleak. Already, it is said, the fishermen of the Chesapeake have turned this discovery to commercial account.

As soon as the fish are taken out of the water they are carefully washed in fresh water to cleanse them of mucus and mud or dirt and then allowed to drip, after which the small scales which cover the outer surface of the skin are scraped off either with a sort of wooden spade or by rubbing two fish together, great care being taken to keep them from being soiled by blood and to have them free from adherent bits of flesh. Since they readily spoil if allowed to lie, undergoing a putrid fermentation attended by an offensive odor, they are promptly placed in a receptacle containing water to which there has been added either 15 centigrams of chloride of silver or else 3 gr. of salicylic acid. Five kilos of scales are required for the preparation of 1 kilo of the essence and to furnish these not less than 38,000 to 40,000 bleak fish of average size are needed. The scales from the back and the belly are kept apart, since the latter are the finer and bring a better price on the market. Before the war this was about 25 fr. per kilo.

When a sufficient number of scales has been collected to justify manufacture, the water covering them is decanted and a suitable quantity of the scales is placed in a large flat mortar made of glazed porcelain. By means of a peculiarly shaped flat pestle the operator proceeds gently to crush the scales, being careful to move the pestle backward and forward instead of around. In this manner they are separated into longitudinal laminæ. As a result of this crushing process the small particles of matter, which impart to the scales their characteristic silvery aspect are gently and gradually detached. After several hours of this treatment pure water is poured into the vessel containing them and they are carefully triturated therein. The silvery particles are reduced by this treatment to a state of extremely fine division, and are extremely light, so that they are held in suspension in the water or else float upon its surface. The mixture is then strained into a tall vessel through a piece of fine linen stretched over its mouth. The water containing the silvery

APPLYING THE ORIENT ESSENCE WITH THE AIR BRUSH

BURNISHING THE PEARL BEADS ON CHAMOIS POWDERED WITH FRENCH CHALK

pigment passes through the meshes of the linen while the scales which have been partly stripped of their coloring matter remain upon the cloth. These scales are put through the same process once more, being bruised and triturated in water, and the latter filtered as before. The double operation is generally sufficient to remove all the pigment.

The filtration liquid is then stirred by means of a mechanical device for five or six hours, after which it is allowed to settle. The pigment collects rapidly at the bottom of the vessel and the water above it is decanted. The moist mass of pigment remaining has a brilliant luster and a charming silver white color; after being dried it yields an extremely fine powder of a grayish silver tint. This is the orient essence and like the scales from which it came it can be

CLIPPING THE BEADS OFF THE WIRES

preserved indefinitely in water to which a small percentage of silver fluoride or salicylic acid has been added. In pure water, on the other hand, it rapidly putrifies and loses its color.

COVERING THE PEARL BEADS

Making the Pearls.—The foundation of an artificial pearl is a small sphere of blown glass. These spheres are obtained from a very thin tube of glass more or less opalescent in tone. Very varied forms can be obtained closely imitating the variety found in natural pearls, but this work must be entrusted to highly-skilled glass blowers, since the wall of the bead must be both extremely thin and very even in its thickness.

Coating the Beads.—In order to be applied either to the inner surface or to the outer surface of the glass beads thus prepared, the orient essence described above must first be mixed with gelatine. White gelatine is used—in France that bearing the trade-mark Coignet. This is first put to swell in water to which 3 per cent of salicylic acid has been added for half an hour, and is then placed in a water in a porcelain vessel where it is very carefully melted after the acidulated water which covered it while it was swelling has been poured off. When entirely dissolved 10 to 12 gr. of the orient essence are added to 10 gr. of the gelatin solution and the two are very carefully mixed together until a perfectly homogeneous product is obtained. This mixture is kept in a fluid state upon the water bath and by means of a pipette tapering to a fine point one or two drops of the preparation are inserted in each hollow ball of glass by means of a small perforation. As soon as this coating has been introduced into the pearl the latter is thrown into a sort of glass cup mounted upon a centrifugator revolving at 1,200 revolutions. The rotary motion thus imparted causes the solution of gelatine and pearl essence to be spread thinly and uniformly on the inner surface of the hollow bead. Here it quickly dries, having upon cooling a hardness like that of cement. Sometimes the pearl essence is spread upon the inner surface of the bead merely by skilful blowing of the operator's breath, in which case the centrifugating apparatus can be dispensed with.

Sometimes the pearls are left hollow, in which case they are naturally very fragile. In the better wares, however, as soon as the coating of essence has hardened properly, the pearl is filled with a mixture consisting of 80 parts of wax and 10 parts of sulphate of baryta, the latter being added to give the pearl a weight approximating that of the natural gem. This filling is accomplished by means of a tapering pipette, the mixture being kept warm at a temperature of about 35° C. upon a water bath.

PEARLS OF SOLID GLASS

Sometimes the pearls are made of solid glass, in which case the pearl essence must be applied to the outside. According to a well-known authority, Maurice de Keghel, former

SORTING THE BEADS ACCORDING TO SIZE

head of the laboratory of the Institute of Applied Sciences, in Paris, most of the famous pearls noted for their marvelous duplication of the genuine gem are made of opaque solid glass, covered externally with orient essence.

In this method of treatment two solutions or rather emulsions of pearl essence are employed, one of which is slightly gelatinous while the other is prepared with acetone. The operator has in front of him small aluminum wires 5 or 6 cm. in length and about 0.5 mm. in diameter, and tapering at each end. One of these is inserted in each pearl as a sort of handle in the threading hole; the operator then dips the pearl in the emulsion of orient essence and rapidly withdraws it, after which he or rather she inserts the opposite end of the wire in a sheet of cork, so that it shall be in as absolutely vertical a position as possible. This causes the pearl essence to spread itself uniformly over the bead while the excess runs down the wire stem. As our picture shows, the pearls now look like white currants on long upright stems. They are allowed to dry in a vertical position, and then each pearl is

dipped in the same manner in the acetone preparation of the orient essence, being again withdrawn with great rapidity and its stem inserted upright in the cork. The acetone evaporates in a few moments and leaves a silvery white iridescent coating indelibly upon the surface of the bead. When very handsome pearls are to be produced this process of alternate dipping and drying is repeated a number of times, even as much as thirty or forty. In recent practice, as shown in one of our engravings, the coating is applied by the use of the air-brush. The orient essence is thus applied very smoothly and of any thickness desired.

When finished their resemblance to genuine pearls of the finest orient is very remarkable. An illustration of this was noted by the writer during a stay in London some years ago. A magnificent necklace of pearls valued, if I remember rightly, at something like $60,000, was on display in one of the cases at Christie's, previous to being offered for sale at that famous auction room. This necklace was the object of admiring attention on the part of a woman of marked distinction and elegance of attire. She came repeatedly to hang over the case in which it lay, and finally, a day or so before the auction was to take place, remarked to the attendant that she thought of bidding upon it, but would like the privilege of examining it for a moment outside the case. The request was granted; she thanked the custodian and swept gracefully away. While there had apparently been nothing suspicious in the transaction, a sudden misgiving smote Christie's man for some reason, and he hastily despatched one of the detectives at hand. The latter caught up with the lady upon the sidewalk and despite her protests insisted upon her return and that a search of her person be made, whereupon it was promptly revealed that she was carrying away with her the genuine necklace for which she had substituted a marvelously faithful imitation prepared by an accomplice from the description which her previous close study of it had made possible. It may be remarked, however, that close as is the imitation there is a difference in the weight which helps the connoisseur to judge between the true and the false.

It is of great importance that the pearl essence employed should be as fresh as possible without the slightest sign of alteration. To test its perfection a trace of formol is added. If the gelatine emulsion is not fresh it rapidly becomes turbid, while the pigment loses its luster and has a flaky look. Under such circumstances it is unfit for use in preparing fine pearls. It is important that the acetone emulsion be kept in the dark and the mixture must never be stirred or disturbed when it is about to be used. Under these circumstances there will be a layer of acetone on top of the pearl essence, and this is necessary. When orient essence is too old it is coarser grained and produces a less perfect imitation.

Typewriter Inks and Ribbons*

An Interesting Review of Some German Methods of Manufacture

BEFORE the War, the manufacture of typewriter inks and ribbons formed an important industry in Germany. Much of the products was exported. In the United States, the consumption of these commodities is very large. The ribbons are made generally by the large concerns which manufacture writing machines, as an adjunct to their main business, while the inks are produced usually by factories which are engaged in the general manufacture of inks and colors. The secrecy with which this manufacture has been surrounded, and the little that has been published concerning the process and formulæ used, make this article, which is concerned with German practice, very interesting.

There are two distinct branches of the manufacture. The first is concerned with the making of the inks, and the second with the impregnation of the ribbons with these inks.

TYPEWRITER INKS

The qualifications of a good ink are as follows:

1. It must be made in such a manner that neither acids nor alkalies are used in its making, or at least in as small amounts as possible. This is important, for the metallic type in the machine must not be corroded or blurred in any way.

2. The ink must not foul or decompose in the ribbon.

3. The ink must impregnate the ribbon in such a way that it yields its color easily, that is, the ribbon must print well. The facility and regularity with which this is accomplished are the determinate factors in the life of the ribbon.

FAST INKS

In former times, inks for writing machines were made in the same manner as those for stamp pads. For example, a much used process for making the ink consisted in dissolving various aniline colors in glycerine and then adding water, according to the following formula: 50 to 100 parts of the aniline color, 800 parts of glycerine and 200 parts of water. The ribbons impregnated with this ink yielded strong distinct impressions, which, however, could not be copied. A great disadvantage of ribbons made in this manner lay in the fact that, when the air was humid, the impressions were indistinct, due to the hygroscopicity of the glycerine, which resulted in the ribbons absorbing considerable water.

A way of correcting this defect was found in compounding the ink in a fatty solvent. This was accomplished by dissolving the coloring matters in hot oleic acid, and adding thereto mineral oil, free from acid. To produce a black ink, nigrosine was used, and various basic dyes and colors trademarked "Ceres" were used for the colored inks. The impressions, made with these inks, cannot be copied.

MORE MODERN PROCESSES

At the present day these processes have been abandoned almost entirely. Ground colors are used generally. To obtain these, cylinder grinders must be used, as the ordinary mortars do not yield a product of sufficient fineness and are incapable of furnishing the inks in large enough quantities. Funnel mills cannot be used, as their grinding action does not yield a fine enough product. Even in the use of the cylinder mills, it is essential to repass the materials through the apparatus several times or at least three times, before it is certain that a pigment of the proper degree of sub-division has been obtained. The finer the grinding the better the quality of the ink. A convenient practical test for ascertaining if the ink has been ground long enough consists in placing a little on a piece of paper and rubbing it over with the finger. If the ink seems to lack uniformity, that is, if the streak of color on the paper shows light and dark spots, then the grinding has not been allowed to proceed far enough and must be continued.

To make black ink the finest lampblack is employed. In the colored inks pigments of all sorts and particularly the aniline colors are used. Mineral colors such as prussian blue and various cinnabar substitutes[1] can be utilized, provided they are ground very fine.

All the pigments are ground in vaseline of the best quality or else in a thick mineral oil. To obtain a medium of greater

*Bruno Walter, *Chemiker Zeitung,* 1921, 21, 169. Translated from the French version in *La Revue des Produits Chimiques,* 1921, 119-120.

[1]Cinnabar or mercury sulphate, also known as vermilion, is too expensive to be used for making red colored typewriter inks. Instead cinnabar of antimony is used considerably. This substance is $(Sb_2S_2O)_3$. It is found in nature and is prepared artificially as well. The process consists in treating (antimony chloride) $SbCl_3$ with $No_25_2O_3$ (hyposulphate of soda) or in heating antimony sulphide in a current of air and steam.—EDITOR.

viscosity about 5 to 10 per cent of mineral wax is added. After the grinding has been brought to the proper point, according to the above test, then about 10 per cent of an oleic acid solution of the pigment ground in the same oil, or rather fatty substances, is added and the mass is mixed very carefully and then put through the grinding mills once again. A typical formula of a black ink is as follows:

Ten parts of very high grade lampblack are ground several times (twice is sufficient for the most part) with 40 parts of odorless vaseline of the best quality. Then 5 parts of a solution of nigrosine in oleic acid are incorporated with the above. The nigrosine solution contains about 50 per cent. of the dyestuff. The mixture is then ground once more. This ink is suited particularly well to the writing of deeds and other important legal documents, as it does not attack the paper and is very resistant to chemical as well as mechanical influences.

The procedure in the manufacture of colored ink is entirely different. Very often after the ink has been compounded, it is necessary to correct the color. A dark color, ground in vaseline or a similar suitable medium will give an impression in the typewriter that is not, for example, blue or violet, but black. When this happens, the pigment must be diluted. This is done generally with the aid of zinc white (finely ground zinc oxide). Sometimes, the shade of the ink is not exactly what was wanted, as for example a green may have too much blue in it. Then, the color may be modified by the admixture of the proper pigments. The amount to add is determined best by practical tests. It is preferable to mix the pigments together in the dry state, before compounding them with the vaseline or the mineral oil, and then after the proper shade has been obtained to put them through the grinding mills. All these inks are not suitable for use where it is desired to make copies of the impressions obtained with them.

COPYING INKS

Aniline colors, that are soluable in water, are substituted for the insoluble pigments in the manufacture of copying inks for use in writing machines. The colors, which are most suitable for this purpose, are the basic dyes, such as: Methyl violet, methylene blue, malachite green, safranine, etc., etc. They are ground in vaseline, which in this case is much more suited to the purpose than the mineral oils. The paste that is obtained in this way is ready for use without the addition of the colors ground in oil.

The impressions made with these inks, are dull, but they assume a brighter tone when they are copied.

In certain factories, they use castor oil or sesame oil instead of vaseline. The following composition of a copying ink is given in a rather old German patent (German patent No. 71,912): Twenty-four parts of the pigments compounded with tar oil are dissolved in 4 parts of castor oil, 2 parts of creosote or phenol and 2 parts of Cassia oil.[2] Other inks are made with saponified oils in which the aniline color is dissolved.

HECTOGRAPHIC INKS

The hectographic inks must include glycerine in their composition. In this case, the inks must be more concentrated than the ordinary inks, for the impressions made with them must yield 50 to 100 copies. To make an ink that contains large quantities of the pigments requires special care in the selection of the dyestuffs and the dilutents and other additional ingredients in order to prevent the colors from crystallizing out of the solution. As far as the intensity of the pigments or dye is concerned, the manufacturers can furnish the necessary information, but the means of preventing the crystallization of the coloring matters are determined best by actual experience. Then we may be reasonably sure of obtaining accurate results. It is known that the addition of acids to the composition increases the solubility of the organic coloring matters. Accordingly, muriatic, or better, the chemically pure hydrochloric acid, is employed generally for this purpose, because of its relatively greater volatility. In using this acid or others of like nature, the deleterious action of acids on the typewriter must be taken into consideration.

A very good ink is obtained in accordance with the following formula: One hundred parts of crystallized violet are dissolved in the hot in 300 parts of 28 degrees Be. glycerine and 190 parts of water. After solution has been effected, 60 parts of hydrochloric acid (20 to 22 degrees Be.) and 50 parts of an aqueous solution of dextrine are added (the dextrine solution contains 50% dextrine).

The action of the dextrine is to facilitate the hectographic printing and to prevent the ink from being absorbed by the paper too copiously. The ribbons, impregnated with this ink, lose the greater part of their acid content rapidly, but retain enough of it to render it necessary to wash the type of the machine carefully, each time the ribbon is used.[3]

TYPEWRITER RIBBONS

It is of prime importance that the ribbon itself be of the best quality. The early ribbons were made from closely woven silk. In present day practice, the ribbons are made exclusively from cotton fabric, manufactured especially for this purpose. It is very essential that the fabric be strong and of a closely woven texture. The ribbon should be free from stiffness and the edges should be woven in such a manner that they do not travel and resist all the mechanical wear and tear that they receive in passing through the different parts of the typewriter. The different sizes of writing machines on the market require that they be made in various widths and lengths.

A method of impregnating the ribbons, which was used very considerably in former times and is used to some extent even at the present time, consists in passing the ribbon through a bath of the ink. The new ribbon is wound on a spool, set a certain height above a shallow vessel containing the ink. The ribbon passes through the ink bath under two rollers, placed at either end of the vat, which keeps the ribbon under the surface of the ink in its course through the bath. The ribbon leaves the vat at the farther end and then is passed between two cylinders, which serve to force the adhering ink into the pores of the fabric and also to rid the ribbon of all excess ink; which flows back into the bath. The finished ribbon then is wound upon another spool. The ribbons, made in this manner, give strong, clear impressions, but after being used a short time, they lose their ink almost entirely, long before the ribbon itself has worn out.

In order to prevent the effectiveness of the ribbon from being destroyed in such short order, the ribbons are no longer impregnated with the ink, but a very thin coating of the ink is fixed on both sides of the ribbon. This coating is so thin that the type in the writing machine neither becomes dirty nor yields blurred impressions. To make such ribbons only inks ground to the consistency of a paste can be used. The new ribbon is passed between two rollers, one of which is smeared with the ink and the other presses the ribbon against the inked roller and causes a coating of the ink to form on the ribbon. The other side of the ribbon is coated in the same way later on. The finished ribbons are wound on the well-known spools or reels, either mechanically or by hand, while passing through measuring devices, which cut off the ribbon at the proper lengths. This method of manufacture is preferable to the first, because the process can be regulated more easily and a more uniform product can be obtained. The finished ribbons are sold in metallic boxes provided with tight fitting covers so as to exclude the air as much as possible, as this tends to cause the ribbon to dry up.

[2]Cassia oil is an important essential oil, distilled from the bark, leaves and twigs of a shrub indigenous to Cochin-China. It is called erroneously cinnamon oil in the U. S. P. The active constituent is cinnamic aldehyde which is made synthetically as well.—EDITOR.

[3]A red hectograph ink which gives good results contains 20 parts of magenta, 20 parts of alcohol, 5 parts of acetic acid, 20 parts of gum (arabic) and 40 parts of water, or else 10 parts of magenta, 10 parts of alcohol, 10 parts of glycerine and 50 parts of water.—EDITOR.

True Nature of Soap Solutions*

New Concept Destined To Be of Great Service in Investigations of "Colloidal Electrolytes"

SOAP solutions have been used by civilized peoples for many hundred years; strangely enough, however, the reason for their action and their actual chemical and physical nature have remained exceedingly obscure until quite recently. To begin with, nobody knew why the detergent power of soap suds, *i.e.*, their ability to wash cloth, etc., clean was greater than that of any other known substance—a fact which was abundantly proved in the war when the lack of soap was greatly felt in Central Europe. The theory of Chevreul that this power depends upon the emulsifying and suspensory character of soap solutions has recently come to the forefront once more through the support given it by Hillyer Spring and other investigators. This quality is in its turn dependent upon the remarkable lowering of the superficial tension of water when soap is dissolved in it, as respects oily fluids or solid particles such as rust, smut, and dirt in general. This lowering of the surface tension makes it possible for soap solution in contrast to ordinary water, to creep in between spots of dirt or stains of oil and surround them so that they can be easily washed away by the rinsing water. The apparently much simpler question as to the constitution of soap solution has been the subject of study at the University of Bristol by McBain and his students, for the last ten years, and these experiments have now furnished a satisfactory explanation of the matter which involves an entirely new concept with regard to the constituents, not only of soap solutions, but, apparently, also applicable to the comprehension of certain albumins, dyestuffs and other high molecular compounds.

The somewhat contradictory theories of earlier investigators were incapable of explaining the manner in which soap dissolves in water, whether in a crystal or a coloid condition and whether split up through hydrolysis or electrolysis. All these questions it is now possible to answer by means of the data obtained from the numerous series of measurements made, not only with respect to genuine soap solutions, *i.e.*, those made from the alkaline salts of the highest fatty acids, but also in the case of the entirely homologous series of the fatty acid alkalies as far down as the acetates—and this at all practicable concentrations and temperatures. To begin with the measurement of the *electrical conductivity*—*i.e.*, at 90° cent.—revealed two surprising facts: A comparatively high degree of conductivity even in very strong soap solutions, and a very curious behavior of the conductivity with respect to the concentration—*e.g.*, while in the case of acetates the equivalent conductivity slowly and regularly decreases as the concentration increases (which corresponds to the gradually decreasing electrolytic dissociation), in the case of the laurates, and still more in that of the myristates, palmitates and stearates, (*i.e.*, the chief constituents of soap). While the decrease is very great at first, in about 0.1 normal solutions the equivalent conductivity increases with the concentration up to about 0.5 n, and not until the higher degrees of concentration are reached does it again exhibit a slight falling off.

At first this remarkable behavior was ascribed to a hydrolytic cleavage of the soaps; McBain, therefore, sought to find a solution for this much debated problem and succeeded in doing this in two ways. He proved both by electrometric measurements with hydrogen electrodes and by means of a determination of the velocity of reaction of a certain decomposition accelerated catalytically by means of alkali in the presence of soap solution, that the concentration of the free OH-ions in soap solution vary according to their concentration only between 0.001 and about 0.003 of the normal; the degree of hydrolysis in a 1-normal soap solution—0.1 per cent and even in a 0.01-n-solution, amounts to only a little over 6 per cent. These experiments prove definitely, therefore, that the fable of an *extensive* decomposition of the soaps in three fatty acids and free alkali is entirely incorrect, and that the hypotheses based upon this theory must be likewise false—such a hypothesis being the explanation of the detergent action. (Furthermore, when there is a hydrolytic splitting up of the soap in the presence of free alkali it is not free fatty acids which are formed but compounds of these with neutral soaps in constantly changeable relations to acid soaps.)

This small amount of splitting off of free alkalis is not capable, as the calculation showed, of explaining the anomalies which are exhibited in the phenomenon of the electric conductivity of soap solutions, hence we must seek some other way to elucidate this. For this purpose we may turn to the physico-chemical processes of *molecular counting* which are based upon the fact that the osmotic pressure and the properties of the solution which depend thereon—vapor tension, boiling point, freezing point, etc.—are proportional to the number of the molecules in one unit of volume of the dissolved substance. Measurements of the boiling point of soap solution are not feasible, as McBain has shown, because it is not practicable to free the soap suds from air, and on this account the partial pressure of the water vapor remains too low. Direct measurements of the vapor tension by means of the tensimeter are very laborious. It is true that measurements of the freezing point can be made, but only in the case of the oleates and the lower fatty acid salts which continue to form homogeneous solutions at 0° cent. By far the greater number of measurements were made by a method which has hitherto been but little employed, but which has been worked out by the authors with great precision; this method is known as the *dew point.* In this method a polished silver cylinder is suspended in the saturated vapor of a soap solution which has been heated to a temperature of 90.00° cent., the silver cylinder being traversed at the same time by a current of water heated to precisely the same temperature as the vapor; when the temperature of the soap solution falls even for a very few tenths of a degree, "dew" is deposited upon the surface of the cylinder. This difference of temperature corresponds to the difference of the vapor tension between the soap solution and water, and by means of a simple calculation we can thus determine the number of molecules in the solution which exert an osmotic action. This is, as we know, in normal crystoloid dissolve substances at least equal to that which results from the analytic concentration, while it is correspondingly greater in electrolytes with respect to the independence of the ions (amounting to as much as double in binary electrolytes).

When the osmotic concentration is found to be *less* than the analytical concentration, this indicates an association—a polymerization of dissolved molecules by means of which their osmotic action is correspondingly decreased or even imperceptible in the case of the coming together of too highly complex colloidal aggregate. For example, McBain and Salmon found the osmotic concentration of a 1-n-potassium stearate solution at 90° cent. to be only 0.42n. From their conductivity, however, it is possible to calculate with comparative accuracy only the concentration of potassium ions up to 0.41n: according to this, therefore, there can be present outside of the potassium ions, only very small quantities of osmotically active crystalloid dissolved constituents are present and both the bearers of the negative charge (*i.e.*, the potassium ions) and the undissociated salt molecules which are doubtless still present must exist in an osmotically inert colloidal form.

Thus McBain is compelled to form the conclusion that the simple anions of soaps in concentrated solution have, for the most part, collected themselves into colloidal aggregates which

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he terms *ion-micellæ, each of which bears numerous negative charges.* Such highly charged particles are in the habit of annexing to themselves by means of electrostatic action water molecules and other neutral molecules, so that apparently the ion-micellæ of soap solutions contain a certain number of water molecules and salt molecules besides the polymarized fatty acid anions. As the degree of dilution increases the proportion of the colloidal constituent diminishes—it amounts, for example, to about 70 per cent in a 0.5-n-potassium stearate solution and in a 0.2-n-solution to about 30 per cent of the total concentration; it decreases in the same manner with a diminution in the homologous series, in which there may be observed a particularly wide gap between the C_{12} chain and C_{10} chain. In the concentrated solutions of the true soaps however, the positive potassium ions or sodium ions and the negative colloidal ion-micellæ may be regarded as the chief constituents. In the case of these multivalent ion-micellæ we must have them to possess great electrolytic mobility on account of their high charge. *This explains the extraordinary conductivity of these solutions* while their high content in colloidal constituents conditions their great viscosity. And the variability of both these properties in accordance with the degree of concentration and with the temperature follows inevitably from this new concept—in other words, the augmentation of the equivalent conductivity with an increase of concentration is to be explained by the increase in formation of the admirably conducted ion-micellæ.

The other peculiarities of soap solutions by which they are also differentiated from the alkali salts of the lower fatty acid, apparently depend likewise upon the content of ion-micellæ; these other properties include their uncommonly low density, their low superficial tension with respect to air and especially with respect to fatty oils and solid substances together with their detergent power. Finally, this new concept is not only of great importance with respect to the explanation of the essential nature of soap solutions, but it is undoubtedly destined to be of great service in the investigation of the many other so-called "colloidal electrolytes," such as those, for example, which exert functions of the utmost importance in the living organism.

Warming Buildings with Refrigerating Plants*

How Our Vast Natural Supply of Low Temperature May Be Utilized—A Parallel in Hydraulics

By Robertson Matthews

Department of Power Engineering, Cornell University

AT last we are showing interest in the conservation of fuel. This agitation really means that we are growing anxious about our supply of high-temperature heat —that heat of high elevation (of temperature) which, like the water of Niagara, will of itself, because of its high elevation, flow to regions of lower elevation, and which, through the agency of engines, can be made to do for us useful work.

In the production of power that heat only is useful which has a higher elevation of temperature than the atmosphere. The laws of the expansion of gases and vapors make imperative the need of such high-temperature heat. But when heat is required to warm buildings, high-temperature heat, to the extent now used, is not an absolute essential.

Consider atmosphere at freezing temperature entering a building. The heat in that atmosphere needs be raised in temperature only 38 deg. F. (that is up to 70 deg. F.) in order to satisfy ordinary room-temperature requirements. Why should we, then, have to use gases at a temperature over 2,000 deg. F. in order to raise the atmosphere through that small range of 28 deg. F.? Even the use for warming purposes of steam at 212 deg. F. means a misuse of high-temperature heat and of heat that costs money. Science proclaims the wisdom of using low-temperature heat for warming purposes.

In the myriads of tons of atmosphere and water on or surrounding this earth there is already stored an enormous quantity of heat—heat that keeps the air and water in their fluid state and at those temperatures which, compared with furnace and oil-engine temperatures, are never greatly below desired room temperature. But this heat is not available inside our dwellings in cold weather because heat, like water, will not, unaided, run up hill. Yet that air and water is a storehouse of heat—of low temperature heat—which but needs the provision of machinery and of effort to elevate it for use to that level (of temperature) at which we desire it.

The process of elevating this low-temperature heat, however, involves two considerations: (1) The means wherewith it can be done; (2) the commercial practicability. This commercial consideration calls for numerical values showing what the saving of high-temperature heat might be. As a start our scheme will be this: By the use of a small quantity of high-temperature heat to make available for warming purposes a much larger quantity of low-temperature heat.

*From *Power*, April 10, 1921.

Before we undertake, however, to consider what would be necessary in order to make low-temperature heat from the atmosphere available for warming buildings, let us get in mind some useful relationships by first seeing under what conditions an abundant supply of low-level water may be made available through the use of a lesser quantity of high-level water.

In Fig. 1 let the lake contain for our needs an unlimited quantity of water, ten feet below the level of the gardens, and therefore at present not available for irrigating them. Above, however, is a plateau where 1,000 cu. yd. of water can be accumulated in a pond, and from a height of 100 ft. supplied to the garden lands. But we need much more water than this 1,000 cu.yd. so let us run a turbine with the water from the pond, the turbine shall drive a pump, and the pump shall raise water from the lake to the gardens.

Will such a plan supply sufficient water? The calculations are simple. We know that a small weight moving through a long distance at the end of a lever, will raise one wheel of an automobile through a short distance. The conditions of pumping in Fig. 1 are comparable to that. With an ideal water turbine and an ideal pump—no mechanical or fluid friction whatever—we may put the work done by the pump as equal to the work obtained from the water turbine. And since the density of the water may be considered as practically the same in both pond and lake, the volumes of water will be respectively proportional to their weights. Then to get the cubic yards of water that it will be theoretically possible to pump from the lake, we may equate, 1,000 cu. yd. $\times$ 100 ft. $=$ cubic yards of water pumped from the lake$\times$10 ft. This gives $\frac{1,000 \times 100}{10} = 10,00\,0$cu. yd. of water pumped from the lake to the gardens when using ideal machinery.

If we take actual machinery and allow one-half of the energy in the falling water to be consumed by the various quantities of friction, then the useful elevation or head of water would be only 50 ft. Hence only 5,000 cu.yd. of water would actually be pumped from the lake to the garden lands. But this would be five times the amount of water used to run the pump. This is somewhat of a gain in available water for the gardens, but even this is not all. For the water that passes through the turbine can be discharged upon the gardens, making a total of 6,000 cu.yd. of water actually made avail-

able. And it was made available not alone because there was water in the pond, but because we recognized the 100-ft. elevation or head that could be utilized to do work.

This illustration may seem far afield from the problem of warming a building, but it illustrates the fact that in order to make our great supplies of water, power or heat available, we must take into account in some form or other what is termed the elevation, or "head."

Today in order to have a desired amount of heat in the water or in the air flowing through the heating system of a building, we use the heat in fuel in much the same way as though it were the water in the pond of Fig. 1 and that it alone were desired at the level of the gardens. In short, we burn fuel, obtain intensely hot gases, then let the heat in these gases flow down hill (a temperature hill in this case) into the air or water which is to convey the heat of the fuel to the remote parts of the building. In so doing, we make available for heating the building even less heat than is in the fuel because part of the heat is lost in the cinders and up the chimney. This is much the same as if in our attempt to let the water from the pond in Fig. 1 flow down on the gardens there were a leak in the pipe or a break in the ditch which would let part of the water from the pond escape. Now, to get upon the gardens even less water than was in the pond is somewhat in contrast with obtaining six times as much water as was in the pond, which we found could be obtained by taking into account the work that could be realized from the falling water. Yet in heating our buildings today, we must have just such an example of waste.

PRESENT HEATING SYSTEM UNSCIENTIFIC

Our present system of heating buildings, it may now be stated, is unscientific in that it does not take into account the amount of work that could be done by the heat of the furnace gases nor—what means even more to us—the amount of heat that could be "pumped up" from below room temperature to a temperature somewhat above that desired in the building by utilizing this work. We attempt at present to utilize the heat in the gases to heat buildings without giving that heat a chance to do work; we simply let the heat run down hill and fail to take advantage of the excellent elevation of temperature that exists. Now the amount of high-temperature heat at our disposal is limited—it depends on our fuel supply—but the amount of low-temperature heat in the air and water around or on this earth is unlimited. Whether heat for warming buildings shall be scarce or plentiful depends on the progress of science and engineering.

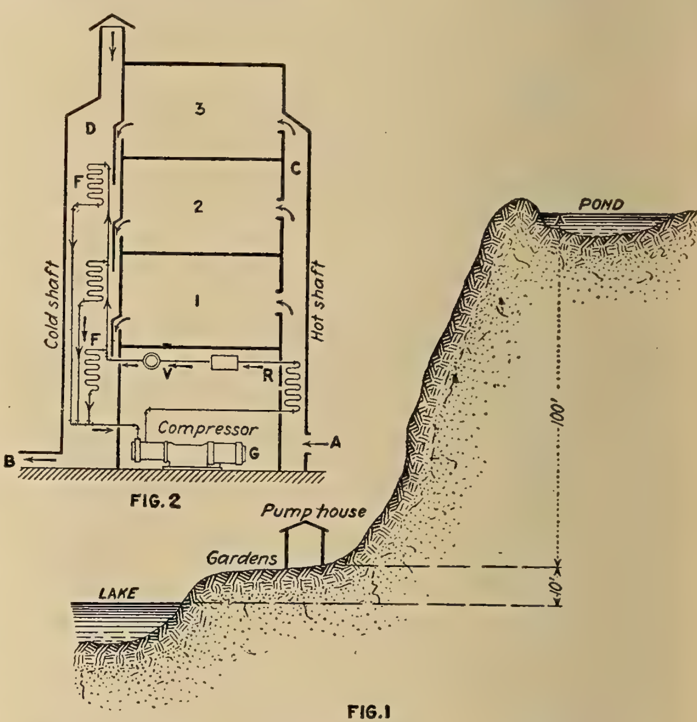
It is now over sixty years since Lord Kelvin proved that the systems used for warming buildings were prodigal of heat. The cheapness of existing appliances for warming buildings was, of course, then as now the deciding consideration. Since that day we have, however, not only improved our heating systems, but have made more marvelous strides in the efficient use of heat in heat engines. At that time oil and gas engines were still in the experimental stage. Today they are the most economical heat users that engineering has so far provided for delivering power, and because of this advance former scientific proposals are now in a fairer way to become commercial realities. We are turning today to mechanical means; that is, by the use of refrigerating machines, to cool our large hotels and auditoriums. That these same heat pumps, for that is what refrigerating machines are, could, if made to withstand a higher pressure, be used for heating our hotels and large dwellings, is not common knowledge. It was Lord Kelvin who first explained that this is the scientific way to heat buildings.

"PUMPING UP" LOW TEMPERATURE HEAT

In Fig. 1 it is shown that an abundance of water was made available by recognizing the possibilities of the 100 ft. head and its application to do work and to operate a pump. Furthermore, the quantities of heat about us which are necessary to keep the tons of air and water in their fluid state and at a temperature not greatly below that which we commonly desire in our homes have already been referred to. The problem, then, becomes one of applying energy and machinery to this great store of low-temperature heat and "pumping it up" to that level at which we desire it. The "head" to be pumped against in this case, is not one of feet of elevation, as when pumping water, but a "head" in degrees of temperature, measured with a thermometer.

But how can we pump heat? Easily enough. We handle heat by applying the same idea that we use in elevating coal, grain or crushed stone: we use a conveyor and handle the heat fast enough to prevent appreciable leakage. The most evident heat conveyors that we are all acquainted with are the air and the water of heating systems for buildings. Our choice here as the conveyor will, however, be ammonia.

Of mechanical apparatus we should have two pieces similar in purpose to those we had in Fig. 1: (1) A turbine or engine



FIGS. 1 AND 2. DIAGRAMS ILLUSTRATING NOVEL USE OF HYDRAULIC HEAD AND ANALOGOUS USE OF THERMAL HEAD FOR WARMING BUILDINGS

to utilize high-temperature heat; (2) a pump to elevate low-temperature heat. And just as we used water to pump water, we can likewise use heat to pump heat, but because we are pumping heat, a somewhat unfamiliar process, we must not let the greater magnitude of heat discharged by the pump over that supplied to run the pump—which conditions our problem will finally show—mislead us into thinking we are attempting the unreasonable. The heat discharged is a measure of the capacity of the heat pump, and the capacity of a heat pump to pump heat must not be confused with heat-engine efficiency in the use of heat.

Those buildings that are equipped with refrigerating machines have already both the required "turbine" and the "heat pump." For, as stated before, the refrigerating machine is a heat pump. But while the "turbine" (engine) could probably meet the necessary load without requiring much change, the "pump" (compressor) might not be capable of safely carrying the necessary pressure. We shall, however, since heat pumps are as yet too costly to be installed for cold-weather use only, assume that a refrigerating machine is already installed for summer use, which is strong enough for the pressures required when the machine is turned over to serve as a warming device in cool weather.

In Fig. 2 a section of a building of several stories is shown

diagrammatically. Refinements of design and equipment will not be considered. The purpose will be to show how practicable the heat pump may be, under some conditions, for warming a building. Considering first the path of the air. Fresh air enters the duct *A* and is heated by coils *E*. The warm air rises in the shaft *C* and enters rooms 1, 2, 3, through the ducts shown. The spent air from the rooms then passes through the ducts provided into air shaft *D*, where it mingles with a stream of atmospheric air that also enters through a suitable duct. In shaft *D* are other coils *F* colder than the mixture of spent air and atmosphere, so that owing to their cooling effect it will, acting as a reversed chimney, serve the double purpose of helping to withdraw the spent air from the rooms and of providing a flow of air across the coils *F* whose function is to absorb low-temperature heat from that air.

Consider next the mechanical operation of the heat pump. Liquid ammonia discharged from the receiver *R* through the expansion valve *V* becomes in part a gas and suffers a drop in temperature. In the coils *F* the cold mixture of liquid and gaseous ammonia takes in heat from the air in the air shaft *D*, and the ammonia may become wholly gasified. Next, the compressor *G* draws in a cylinderful of the ammonia gas and compresses it. But the work of compressing the gas raises its temperature, and we compress it enough to get the

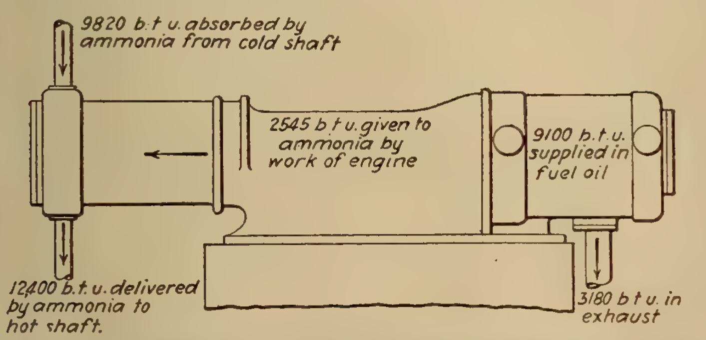


FIG. 3. DIAGRAMMATIC ILLUSTRATION OF HEAT UNIT TRANSFERENCE BY AMMONIA COMPRESSOR

temperature desired in the coils *E*, which in turn give up the high-temperature heat of the ammonia to the fresh air entering the shaft *C* by way of the duct *A*, and this chills the ammonia, which condenses and returns to the receiver *R* as a liquid. For simplicity, the double system of coils by which, for the sake of safety, the ammonia would be made first to heat water, which in turn would heat the air, is not shown, nor is any system of radiators which could take the place of the heating done upon the air in shaft *C*.

MINOR HEAT LEAKAGES IGNORED

Coming next to the path of the heat we ignore minor heat leakages. Low-temperature heat in the cold-air shaft *D* is picked up by the cold ammonia (the conveyor) and is carried over to air shaft *C* with the progress of the ammonia. On the way over, however, the quantity of heat in the ammonia is increased, for the compressor does work upon it, and just as a gas or a vapor, when it expands behind a piston, converts into work some of the heat it contains, the reverse, or a conversion of work into heat, which heat goes to increase the heat already in the ammonia, takes place when compression occurs. On the way over, then, the compressor increases the pressure, the temperature and the heat content of the ammonia, and the amount of heat thus added to the ammonia will be the equivalent of the foot-pounds of work that the engine delivers to the compressor end of the machine. If, then, we let *Q* stand for "quantity of heat," we shall have, when the ammonia arrives in the hot coils, an amount of heat available for discharge to the fresh air of shaft *C* equal to the *Q* absorbed in shaft *D* plus the *Q* added by the work of the compressor. This is comparable to the operation in Fig. 1, where the water drawn up from the lake plus the water fed to the turbine become as a combined quantity available for watering the gardens.

The compressor has now accomplished two things—it has increased by a definite amount the heat in the ammonia over the amount that was absorbed from the cold air, and it has raised the pressure and temperature of the ammonia till, as a result, it is possible for both that *Q* obtained from the cold air and that *Q* added in the compressor to flow into the warm air shaft. This is a most happy result for our undertaking. The proof that this result is possible requires the use of diagrams which will not be introduced here. Let it suffice, therefore, to recall the results in Fig. 1, where the lake water plus the water that does the work are eventually combined and discharged upon the land. Reviewing the path of the heat, low-temperature heat is absorbed in shaft *D*, this heat, while being conveyed across to shaft *C*, is increased and also raised in temperature by the compressor; then what has now become high-temperature heat is discharged into shaft *C*. The ammonia is condensed and returns by way of the receiver and expansion valve to repeat its conveying functions.

What, now, is the magnitude of the amount of heat given to the air in shaft *C* compared with the heat supplied to make that warming possible? This will be shown later. For the present assume the compressor is driven by an oil engine (see Fig. 3). If, now, in our chosen installation the number of heat units in the fuel oil supplied to the engine—in order that the engine may impart to the compressor work enough to compress the ammonia—be less than the amount of heat discharged to the fresh air in shaft *C*, then we shall have a system that discharges more heat than we put into it. This is something a house furnace cannot do.

PERPETUAL MOTION NOT ATTEMPTED

Going back to the problem of getting water upon the gardens, perpetual motion was not obtained when more water was delivered upon the gardens than was used to pump that water, nor was any attempt made to get the water fed to the turbine to return to the pond. To have tried to do so would have been an attempt at perpetual motion. What was really done was to take a small quantity of water from the pond, let it do work and then allow it to remain at a greatly lower level. The same reasoning applies to our use of heat in the heat pump; we have gained in the quantity of heat at our disposal for heating purposes, but have sacrificed, for part of that heat, an enormous elevation of temperature. We have raised some heat from perhaps 35 deg. to 125 deg. fahr., but have also let down other heat in the cylinder of the oil engine from perhaps 2,500 deg. to 900 deg. fahr.

Because the heat pump involves a "conveyor" (the ammonia) the operations are not so direct as with the water turbine and its pump. For example, in the water turbine all the water supplied to it goes to join the water pumped; in the heat turbine (the oil engine) all the heat supplied to it does not go to join the heat "pumped up," but owing to the limitations of heat engines most of the heat in the fuel supplied to the engine goes finally out in the exhaust and jacket water. In our job, however, much of this "waste heat" could be used in air shaft *C* to help boost the temperature. Were the heat engine as efficient in converting potential energy into work as is the water turbine, our problem would work out much better than it does.

A SPECIFIC PROBLEM EXPLAINED

Our undertaking has now narrowed down to running the ammonia compressor at a high enough discharge pressure to give condensing water sufficiently hot to warm the fresh-air supply. It remains to show by calculation whether it would be more profitable from the point of view of heat economy to operate the refrigerating machine instead of a boiler or furnace in order to warm the building in cool weather.

Let us consider first a cool, rather than a cold-weather problem; the atmosphere to be not below 40 deg. fahr., and that the mixture of spent and fresh air will leave the shaft *D* at a temperature not below 35 deg. fahr. We shall assume the following data and conditions: For simplicity in calculations we shall let the oil engine deliver to the compressor one horsepower-hour, or the equivalent in work of 2,545 B.t.u. per hour.

We shall ignore jacket effect for the compressor and consider no pre-cooling of the ammonia. These are two conditions unfavorable to our problem.

We shall, further, ignore the heat leakage in connections between pieces of apparatus and shall assume the ammonia enters the compressor in dry saturated state.

Heat value of fuel oil, 18,200 B.t.u. per pound.

Fuel consumption of oil engine per brake horsepower-hour, 0.5 lb.

Suction pressure in ammonia compressor, 53 lb. absolute; corresponding temperature in cold oils, 25 deg. fahr.

Discharge pressure in ammonia compressor, 312 lb. absolute; corresponding saturation temperature in hot coils (condenser), 125 deg. fahr.

We desire to find the ratio of the heat supplied by the heat pump to the heat supplied by a boiler and furnace. The same amount of fuel oil to be used in both cases, and the heat to be delivered to the hot coils in shaft *C*.

Referring to Fig. 3, the engine is supplied with $0.5 \times 18{,}200$, or 9,100 B.t.u. per brake horsepower-hour. Of these 9,100 B.t.u., say 35 per cent or 3,180 B.t.u., go out in the exhaust. This "waste heat" could be utilized to heat air in shaft *C*. Other 2,545 B.t.u., the equivalent of one horsepower-hour, go to do work at the compressor and upon the ammonia. These 2,545 B.t.u., together with the B.t.u. absorbed from the cold coils will give the number of B.t.u. supplied to the hot coils by the heat pump when 0.5 lb. of fuel oil is used.

But how many B.t.u. are absorbed from the cold coils when 2,545 B.t.u. are supplied as work done on the ammonia? For the answer we must refer to tables and chart of ammonia properties (see "Mark's Hand-book," pages 333 to 335).

From the hand-book we find that (per pound of ammonia circulated) the amount of heat absorbed from the cold coils in shaft *D* will, for the conditions chosen, be 436 B.t.u. We further find that the amount of work done on one pound of ammonia while passing through the compressor will be equivalent to 113 B.t.u. Now these two quantities combined, or 549 B.t.u., is the amount of heat supplied to the hot coils for every pound of ammonia circulated. Hence, if 549 B.t.u. are discharged into the hot coils every time that 113 B.t.u. are added to the ammonia because of the work done on it in the compressor, it follows that the number of B.t.u. discharged into the hot coils when 2,545 B.t.u. are supplied as work upon the ammonia, will be $2{,}545 \times \frac{549}{113} = 12{,}400$ B.t.u. Using the same quantity of oil under a boiler and allowing a boiler and furnace efficiency of 75 per cent, the heat that could be supplied to the coils in shaft *C* would be $0.5 \times 18{,}200 \times 0.75 =$ 6,820 B.t.u.

From these values we get the ratio of heat supplied by heat pump to heat supplied by boiler and furnace as $\frac{12{,}400}{6{,}820} = 1.82$. With the heat of the exhaust fully utilized, the ratio becomes $\frac{15{,}580}{6{,}820} = 2.28$.

Were it necessary to have the suction temperature zero deg. fahr., then the heat pump would deliver but 9,750 B.t.u. when 0.5 lb. of fuel oil was supplied, and the ratio becomes only 1.43. In this case, however, a large amount of precooling could be obtained, which would boost the value of the ratio, as would also the jacket effect, which would be essential here in order to keep down an extreme amount of superheat. Further, we might have to resort to mechanical means for defrosting the coils in shaft *D*.

The commercially permissible operating conditions depend, of course, on the price of fuel, since that together with the hours of operation determine the allowable investment in heating surfaces. The ideal condition would seemingly be to make ice while pumping heat, but the output of ice would probably be too vast for storage capacity.

With the compressor driven by electric motor and with the compressor piston receiving 68 per cent of the energy supplied to the motor, the heat pump would deliver, under conditions of the original problem, 11,330 B.t.u. to the coils per kilowatt-hour supplied to the motor. One kilowatt-hour converted directly into heat would give but 3,412 B.t.u. Dividing 11,330 by 3,412 gives a ratio of 3.32. This value, of course, takes into account no steam-electric plant losses and is worth considering only with hydroelectric power.

The manner in which the improvement in oil-engine economy advances the possibilities of the heat pump can be shown if we assume that for a steam-driven heat pump three pounds of coal with 13,200 B.t.u. per pound, would be needed per brake horsepower-hour of engine. These three pounds of coal burned under a boiler, with a boiler and grate efficiency of 65 per cent could deliver to the coils $3 \times 13{,}200 \times 0.65 = 25{,}700$ B.t.u. Now for the conditions of the original problem, 12,400 B.t.u. are delivered by the heat pump per brake horsepower-hour supplied. This gives a ratio of $12{,}400 \div 25{,}700 = 0.48$ only. Were the heat pump steam-driven, the steam might better be used direct from boiler to coils.

The temperature of 125 deg. fahr. selected for the hot coils would call for the use of extensive heating surface. Higher temperatures are obtainable, of course, if we submit to the increasingly higher pressures and to the smaller ratio which corresponds with an increase in the work required. Without tabulating more values of the ratio, it may be stated that the work required increases at a slightly diminishing rate as higher temperatures in the hot coil are selected.

HOW TO WELD CAST IRON ELECTRICALLY

THE difficulty in welding cast iron with the electric arc is not encountered because the metal cannot be properly fused, but is due to the fact that the sudden intense heat of the arc over a local area results in the production of a hard weld and the introduction of contraction stresses which often result in cracking. Using the carbon welding process, cast iron welding rods may be fused into a cast iron piece. Using the metal electrode process and a soft iron or steel electrode, it is impossible to make a reliable weld between the added material and the cast iron. Using the metal electrode process certain work can be done by the introduction of steel studs in the cast iron pieces to be welded together so that a certain amount of strength is obtained by the bond formed between the steel studs by the welded material. For welding small gray iron castings a 3/16-inch cast-iron welding rod and 300 amperes welding capacity are required. A small gray iron casting should be broken and the edges beveled, using the carbon arc for cutting. The pieces should then be placed in a carbon mold so that the molten iron when it is added will not run away from the joint. The carbon arc should be used to preheat the casting. It is not necessary to heat the pieces to a red heat. The carbon arc and cast iron welding rod should then be used to fuse the added material to the piece. Care should be exercised not to play the arc upon the weld any longer than is necessary to give complete fusion. In case the metal gets too hot and runs badly the arc must be broken, and an interval of time allowed for it to cool slightly to eliminate the trouble. After the weld is completed the piece should be wrapped securely in asbestos paper and allowed to cool slowly for six or eight hours; larger pieces require as long as 24 hours to cool.

As an alternative to wrapping in asbestos paper the piece may be covered in previously heated slacked lime.—*Foundry*, January 15, 1921, p. 68.

Blast Furnace Flue Dust Recovery*

A Direct Process of Wet Recovery Which Avoids the Necessity for Sintering or Briquetting

By George B. Cramp

WITH a plentiful water supply available, other considerations in connection with the installation of a wet washing system for cleaning blast furnace gas, and incidentally a flue dust recovery system are:

1. Dry dust catchers for receiving and holding the heavier dust particles such as are carried from the blast furnace by the gas under normal working conditions, and also the bulkier coke, ore and limestone stock thrown from the furnace during a slip.

2. Wet gas washers or scrubbers for washing out of the gas all dust remaining therein after having passed through the dry dust catcher.

3. Disposal of the dirty wash water from the gas washers or other apparatus in which the water has been used in any manner to wash dust from the gas.

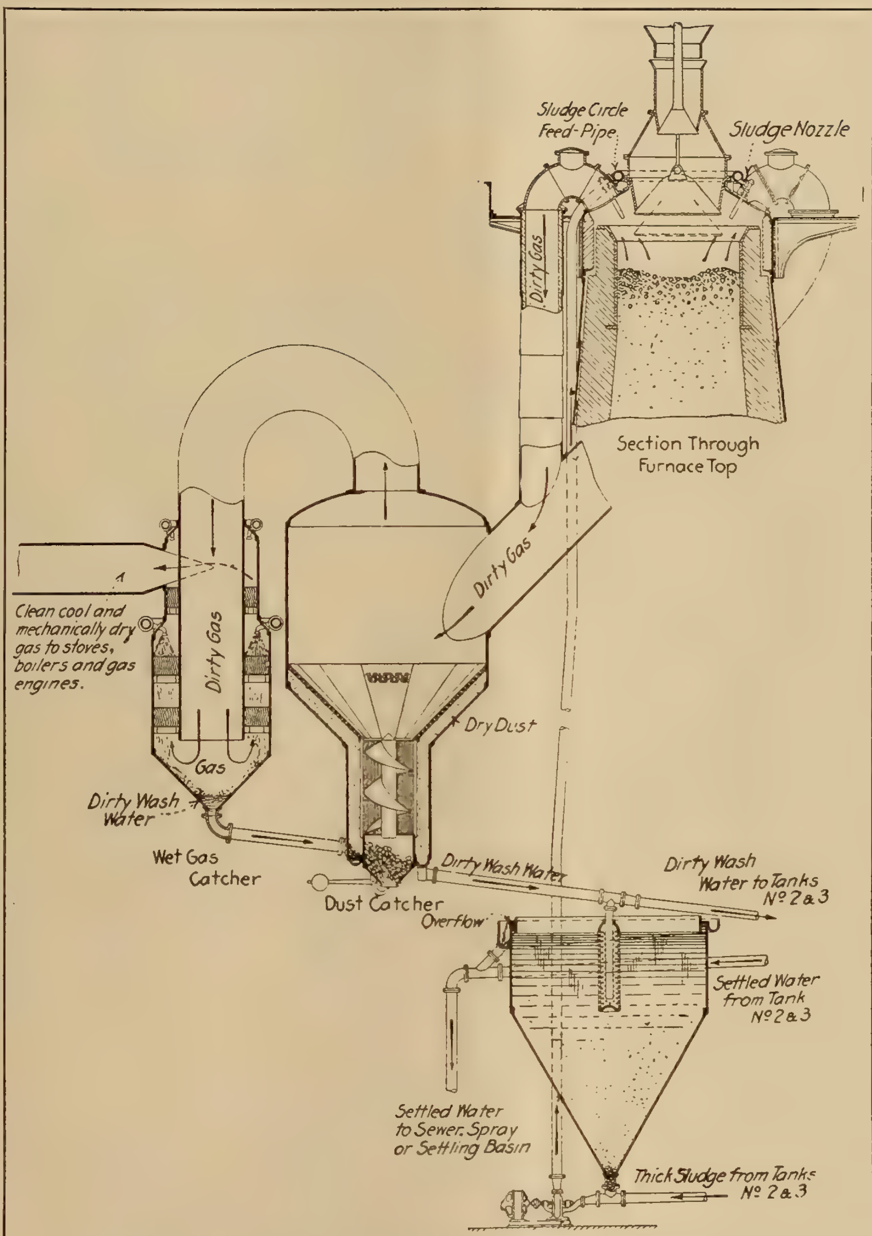
4. Recovery and treatment of the wet dust from the wash water, along with the flue dust recovered in a dry state from the dry dust catchers.

5. Method to be used in recharging the recovered flue dust into the blast furnace.

The foregoing considerations will be taken up in order with a view to outlining present practice, pointing out imperfections and suggesting improvements, and with the further object of accomplishing a coordinated arrangement of improved apparatus which will satisfactorily and effectively recover and recharge into each particular furnace practically all flue dust produced by that furnace, at the furnace site, and will accomplish this direct recovery of flue dust automatically, continuously and without labor or transportation cost, and with a minimum water and power requirement.

Though practice at various blast furnace plants differs as to the number and size of the dry dust catchers used, there is but slight difference in their design. They are usually of cylindrical shape with inverted conical bottom which forms a hopper for the dust and larger stock deposited. The top is usually dome shape or conical, and the downcomer or downcomers which conduct the gas from the top of the blast furnace, enter through the top or the side of the dust catcher. The gas outlet connection may occur at either place, but preferably opposite, or as far from the inlet or downcomer connection as possible. There is but little advantage gained by either arrangement, however, as the amount of dust precipitated in the dust catcher varies in accordance with the velocity and dust content of the gas passing through it, and the larger the dust catcher the lower the velocity of the gas moving through it and the greater the dust precipitation therein.

Not much has been done toward accomplishing anything within the dust catcher other than what has just been related; but the dry dust catcher offers great possibilities in the economic handling of flue dust if designed as a separator for separating flue dust from the larger coke, ore and limestone stock discharged from the furnace during a slip. Separation of these grades would permit the fine dust to be sluiced or flushed out of the separator with the same water that is previously used to wash the gas in the wet gas washer, thus combining all flue dust and necessitating but one method of handling thereafter. The larger stock brought down within the separator is freed from dust and held within the separator until drawn off into cars, and taken to the ore or coke bins to be recharged into the furnace.



DIAGRAMATIC VIEW OF NEW PROCESS OF RECOVERING FLUE DUST

The dust is separated from larger particles and flushed out; then sludge is pumped directly into top of furnace

The improvements in dust catcher design just proposed are met in the design shown in the drawing. The first and greatest saving in cost of handling flue dust and recovery of

*From the *Iron Age* March 24, 1921.

bulkier stock is possible of realization in this improved design, which may be termed the most vital of any of the improvements proposed, as it pre-determines the extremely simple methods of handling the flue dust in wet form made possible by the separating and dust flushing features of the design.

DUST PRECIPITATION IN INSTALLMENTS

At some plants further efforts are made to precipitate dust in the dry state, between the dry dust catcher and the wet gas washers, by installations of secondary dust catchers, dust legs or pockets and dry whirlers; all of which catch some dust as the gas passes through them. This would occur, however, if an almost infinite number of pieces of apparatus were used to recover the dust in a dry state, and it is for this reason that recent practice has inclined toward the omission of all dry dust catching devices between the first dry dust catcher and the wet gas washer, and installing the gas washer as close to the dust catcher as possible, so that the connecting gas main may be shortened to the minimum and otherwise arranged to be self-cleaning, in that no dust will find a lodging place throughout its length.

TYPES OF GAS WASHER DESIGN

Wet gas washer design has in the past covered widely different views on various types of apparatus for accomplishing the washing of dust from blast furnace gas, using water as the washing medium. All these types of washers may be roughly arranged into two groups: power-driven and stationary washers. Of the power-driven washers the Thiessein is a good example, and is one of the few designs of power-driven washers remaining in practical use; and this for secondary or final washing only, it being entirely out of consideration as a primary washer or scrubber.

In the stationary group of washers the rain or spray type, and the baffle types, form two subdivisions. By rain or spray type is meant those washers or scrubbers, as they are more often called, wherein a rain or spray of water is dropped from a considerable height withn a tower through which the gas travels upward, the dust carried by the gas being washed out by contact with the spray of water.

Within the baffle type washers sprays of water are directed on baffles made of wood or metal, the surfaces of which serve to retard the water as it falls from top to bottom of the scrubber. The baffles are so arranged that they split up the gas body as it travels upward through the scrubber and thus cause the gas to come into more intimate and positive contact with the wet surfaces of the baffles, on which much of the dust impinges and is then washed off by the continuous spray of water directed on them.

Of the two types of stationary washers just described, the baffle type has proved to be of greater efficiency for two reasons. In the rain or spray type scrubber there are usually heavier sprays of water required to break up the gas body and penetrate it. Gas in moving through a spray acts much like wind with rain in a storm, a strong wind often being seen to blow sheets of rain at a sharp angle to the perpendicular. Gas acts likewise in a spray type scrubber, except that, being confined within the scrubber, the gas tends to travel through the spray. In a well arranged baffle scrubber, on the other hand, channeling is practically eliminated, as the gas is split up into thin bodies which are compelled to travel between two wet walls which prevent their surging or channeling. A further advantage is gained by the baffles in that they retard the fall of water, thus bringing a given quantity of water into longer contact with the gas, and causing it thereby to wash out more dust from the gas.

ACTION OF THE BAFFLES

The nature and position of baffles within a gas scrubber are determined by simple considerations. If a wet board or sheet of metal one foot square is projected into a moving body of dirty gas, with its greatest area at right angles to the direction the gas is moving, it will be found to pick up no more dust from the dirty gas than if turned ninety degrees to the original position, while the resistance to the moving body of gas, with the baffles in the first position, would be much greater. It is for this reason that baffles are set edgewise or parallel to the direction of gas flow.

After exposure of one square foot of wet baffle surface to a body of dirty gas in the manner just described, it will be found to have collected a certain amount of dust in a given length of time. If twice the area of baffle surface is exposed to the dirty gas about double the amount of dust will be collected, and by provision of ample baffle surface a given volume of gas, of given dust content, is continuously cleaned or washed of dust by the action of the water spray directed on the baffles.

In the selection of materials for baffles, wood is usually chosen, mainly because it is a cheaper material and because it can be readily built into the scrubber. Wooden baffles, however, have some serious disadvantages. One of these is their bulk. They are usually about an inch thick, and as the spaces between baffles cannot be much less than an inch, because of the tendency to warp and thus close the openings between them, it is readily seen that baffles of wood occupy one-half of the cross sectional area of the scrubber in which they are placed. On this account a scrubber shell is necessary of twice the area that would be required if thin plates or sheets not over 1/32 in. thick were used. This is a very serious consideration when arranging spray water distribution, as the area over which a given quantity of water is to be sprayed is about twice as great with wooden baffles as would be required with thin sheet baffles.

A further objection to wooden baffles is their liability to being over dried and warped if the water should go off the scrubber while in operation, while at least one instance is known where the baffles have taken fire during construction, causing the scrubber shell to buckle badly.

DRYING THE SCRUBBED GAS

After having been washed by contact with wet baffles and spray, the gas has been cooled and cleaned of practically all dust. But on leaving the scrubber it carries with it considerable entrained moisture in the form of fine water mist, which has been picked up and carried along by the gas as it moves out of the scrubber at high velocity. It is, therefore, very desirable to remove this moisture, if possible, within the scrubber, and much of it may be removed by causing the gas to impinge on baffle surfaces not sprayed constantly with water. The moisture in the gas coming in contact with the baffle surfaces gathers on them, and forming in drops, trickles down and off the baffles. For removal of moisture from gas in this manner the wooden baffle is not well suited because of its bulk, and as considerable drying area is necessary, it would be impractical to consider this construction within a scrubber.

DISPOSAL OF WASHER WATER

Probably as great a problem as that of gas washing itself is met with in considering proper methods for the disposal of dirty water from the gas washer. Government restrictions have in the past, and will in the future, make it more imperative that water which has been used in blast furnace gas washers be first settled in properly constructed tanks, basins, or ponds of sufficient size to accomplish the retention of most of the dirt from the water before it is turned into public water-courses, where it rapidly clogs or obstructs the channels, the yearly deposits from one furnace alone being enormous.

From an economic viewpoint it is even more important that the gas washer water should be made to yield up its valuable burden of latent raw material. Several different designs of settling basins are in use, in most cases it being the practice to divert the water from all scrubbers to one basin. For this reason the basin must be of such large dimensions as to necessitate its being located some distance from the furnaces or scrubbers.

The basin may be of single compartment construction or, more usually, of two or more compartments, which permit of one being cleaned of the deposited flue dust sludge while the dirty wash water flows through the other. Cleaning or dredging is done with a locomotive, or overhead electric crane. A more recently developed design of settling basin provides settlement and cleaning continuously in one circular basin, the cleaning being accomplished by use of a bottom scraper or plow mechanism which works the sludge toward the center of the basin, from which point it is then pumped.

At plants where it is the practice to recharge the wet sludge into the furnace, it would be a decided advantage to settle the dirty wash water in two or three tanks, the diameters of which need not be over twenty-two feet with a depth of ten feet. Settling tanks of this size could, in most plants, be located near the furnace. The tanks should be of deep conical bottom construction, in which sludge could settle to considerable depth, for the greater the depth attained the more dense and less watery the sludge becomes. With this arrangement sludge at almost any desired consistency could be tapped off at the bottom of the tank and charged as desired.

HANDLING THE ENTRAINED DUST

Where it is regular practice to charge into the furnace all flue dust recovered in the wet form, and where it would be desirable to charge in the wet state all dust produced, the problem is further complicated because of the dust recovered dry, which amounts to more than that recovered wet. Dry dust at some plants, and both wet and dry dust at others, is transported to a sintering or briqueting plant, and after treatment, is returned to the furnace and charged in the usual way. Consideration of the sintering or briqueting processes for treatment of flue dust is obviated, however, if the dust is all combined and brought down in the wet form as suggested above, which leaves for consideration only the method of charging the flue dust into the furnace.

Where flue dust is treated by either the sintering or briqueting process, the method of charging is simple. The product is dumped into the stock bins at the furnace, charged into the stock larry car and thence into the skip car, as is all the coke, ore and limestone charged into the furnace.

OBJECTIONS TO CHARGING WET FLUE DUST

Where all flue dust is to be brought down in the wet form, however, the method of charging is a matter of serious consideration. It has already been stated that at some plants wet flue dust is charged directly into the blast furnace without being either sintered or briqueted. This practice is not accomplished without considerable cost of handling and other inconvenience, and thus far no standardized system of handling or charging seems to have been developed.

At some plants both dry dust and all ore charged into the furnace are wet down with water just after being dumped into the skip car and before it is hoisted to the top of the furnace. An objection is always raised to this practice, however, because of the fouling effects of wet stock in the skip car and on the charging mechanism; but where the recovery of all flue dust in wet form is accomplished as previously suggested, the charging of wet sludge is greatly simplified by application of the hydraulic system for lifting the wet sludge through a pipe to the top of the furnace, where it can be easily distributed within the furnace through a circle pipe and specally designed nozzles which pierce the top cone of the furnace and introduce the sludge without bringing it into contact with any of the charging mechanism.

SPECIAL DUST CATCHER DESIGN

The foregoing description of methods, practice and apparatus, with suggestions for improvement, is based on actual operation, recent development or experiment. The design of apparatus required to accomplish the suggested improvements, however, is represented in the accompanying drawing.

The dust catcher shown is of about the usual design, except that it has, about 18 inches above and inside its conical bottom, a false conical bottom of plates having ¼-inch slots so arranged as to allow all fine dust and particles smaller than ¼ inch to pass from the upper to the lower chamber, which chambers are formed by the false bottom. The dust after passing through the false bottom drops into the true bottom of the dust catcher, and slides thence into the dust flushing well, where it is flushed out by the dirty wash water from the gas washer.

Any particles brought down in the dust catcher that are too large to pass through the ¼-inch slots in the false bottom simply slide down the false bottom into the helical chute in the bottom center of the dust catcher-separator. This helical chute is encased in a cylindrical cage of bars with ¼-inch spaces between them. In ordinary operation this chute would not be required, but in cases of bad furnace slips, when tremendous quantities of coke, ore and limestone with much fine dust are suddenly thrown into the separator, much of the fine dust would remain unseparated except for the presence of the helical chute, down which all this stock must pass on being dropped out of the dust catcher-separator, into cars in which it is carried to the stock bins. The chute inclines all material rolling down it against the encaging bars and the fines, or particles smaller than ¼ inch sift out between the bars into the flushing well.

By this separation much valuable stock is immediately made available for recharging into the furnace, and without cost for screening or otherwise handling, except transportation to the stock bins. The fine dust separated within the separator is carried out of the flushing well by the water from the gas washer, thus eliminating all cost of handling and treating in the dry state.

After dropping much of the heavier dust in the separator, the gas passes through a self-cleaning gas main into the gas washer. It enters through the drop leg of this main, which drops vertically into the center of the washer. The purpose of this construction is to accomplish perfect gas distribution on entering the washer and drop a great part of the heavier dust—still carried by the gas—immediately into the bottom of the washer. A further object is to permit the washer to be used as a water seal gas valve. By this arrangement the transverse sectional area of the washer is lost to gas cleaning to the extent of the transverse sectional area of the gas main dropping through it, but the thin corrugated sheet metal baffles suggested occupy so little of the transverse sectional area of the washer, effective for gas washing, that the shell diameter of the washer may be even less than scrubbers in which wooden baffles are used. Furthermore, the area over which water spray must be distributed is so much less than that of larger diameters that a material increase in gas washing efficiency is obtained.

On entering the washer through the open end of the drop leg of the gas main, the gas turns an angle of 180 degrees and rises uniformly up through the torrent of falling water, and begins to pass through the lower set of baffles, which are of thin corrugated sheet metal and spaced about ¾ inch apart, being held thus by simple indentations of the corrugations which occur at odd points on the sheets.

CLEANSING EFFECT OF THE BAFFLES

In the lower baffles the gas is subjected to 80 square feet of cleaning surface for each square foot in the area of the entering pipe, using a standard 200 3-inch width of corrugated sheet. The gas is thereby cooled and cleaned of the heavier dust, which, combining with the water flowing down the surfaces of the baffles, is continuously washed into the bottom, and thence out of the gas washer.

Still rising upward, the gas passes through a second set of baffles similar in construction to those just described, but spaced ⅜ inch apart. In passing through these baffles it is subjected to 160 square feet of additional cleaning surface,

and is here thoroughly cleaned of dust and cooled to within a few degrees of the entering wash water.

The gas travels through these baffles at about half its velocity in the entering main, but above the continuous spray nozzles shown on the washer the shell is contracted to a smaller diameter, which increases the gas velocity to that in the entering main. As has already been described, this increased velocity of the gas causes more forceful impingement of the water mist it has picked up in the lower part of the washer, against the dry or unsprayed baffles set in this section of the washer. These baffles are spaced about 3/16 inch apart and the gas in passing through them is subjected to 320 square feet of drying surface. As the mist continues to impinge on the baffle surfaces it forms into drops and flows down their surfaces and into the lower part of the washer.

Cleaning, cooling and drying the gas of entrained moisture is in this manner accomplished in one piece of apparatus, thus providing gas which may be carried through comparatively small unlined mains to the stoves, boilers, or gas engines. The compact baffle arrangement permits the bottom of the washer to be raised to a level sufficiently high to allow the dirty wash water flowing from the washer to enter the dust catcher-separator, where it picks up additional dust, and goes thence to the settling tanks.

Dirty wash water carrying all dust brought down in the gas washer and dust catcher is thus run by gravity through straight pipes to the settling tanks, which for a modern furnace plant would be three in number, and about 22 feet in diameter, or 20 feet square, with a depth of about 10 feet on the sides, which would permit of their being located in most furnace plants in line with the dust catcher and beyond it. The water enters the tanks through a seal pipe, which prevents gas at all times from escaping from the dust catcher with the water. The water passes out into the tank through a perforated distributing pipe and thence travels at an ever decreasing rate to the side wall of the tank, where it overflows. In passing slowly through the tank, about 90 per cent of the flue dust in the water is precipitated and settles into the steep conical bottom of the tank in the form of a silt-like deposit or sludge. The water flowing over the weir wall of the tank drops into a trough running around the tank and thence flows through a pipe to the sewer, which may carry it to a nearby stream or settling basin, or to a spray pond if the same water is to be used over again.

As the sludge settles to the bottom of tank to increasing depths, water is to a great extent displaced by the pressure of the upper mass of material, so that at the bottom of the tank where it is removed through the sludge pipe the sludge would, under proper working conditions, contain not much in excess of 35 per cent water, which would permit of its being immediately charged into the furnace.

The nature and consistency of the recovered sludge make it possible to charge hydraulically with a high-head centrifugal sludge pump, with a power requirement of not more than 5 electrical horsepower running continuously.

CHARGING THE SLUDGE INTO THE FURNACE

The sludge is collected and pumped through comparatively large pipes to reduce abrasion. It enters the top of the furnace through a circle pipe and specially designed nozzles piercing the top cone of the furnace. The nozzle openings are flat and are of sufficient number to distribute uniformly a ring of sludge on to the stock just under the large bell. This sludge ring distributes itself over the stock and the new charges of stock are dropped in on the sludge layers. Excess moisture in the sludge is therefore rapidly absorbed by upper and lower stock layers, thus accomplishing a wetting down of all stock and lessening dust production.

ADVANTAGES OF PROPOSED SYSTEM

The advantages gained by this system are:

1. Separation of fine flue dust from the bulkier stock is immediately accomplished, and the large stock made available for charging into the furnace.

2. The fine flue dust is flushed out of the dust catcher-separator continuously by the same wash water that has previously been used for gas washing.

3. The gas is thoroughly cleaned, cooled and mechanically dried, and may be conducted through relatively small unlined mains to small-checker stoves, boilers, or gas engines.

4. The water used in the gas washer carries all dust from both washer and separator to the settling tanks, where all but about 10 per cent of the dust is recovered from the water in wet form, thus eliminating all cost of handling and treating contingent on recovery of dust in dry form, or when recovered part wet and part dry.

5. All dust recovered in wet form is immediately available for charging into the furnace, eliminating the necessity of treatment by either the briqueting or sintering process.

6. Flue dust in wet or sludge form may be pumped into the top of the furnace, accomplishing the wetting down of all stock and consequent retention of much of the dust that would otherwise be blown out of the furnace.

7. Recovery of flue dust is accomplished at each furnace, making possible the recharging of the same flue dust produced by that furnace.

8. The dirty gas washer water is sufficiently purified to permit of its being run into a public water-course.

9. Water, power, transportation, labor and operating costs for this recovery process are less than that of any other.

10. The first cost of constructing a direct recovery plant is negligible compared to that of plants for treatment of flue dust by any other process.

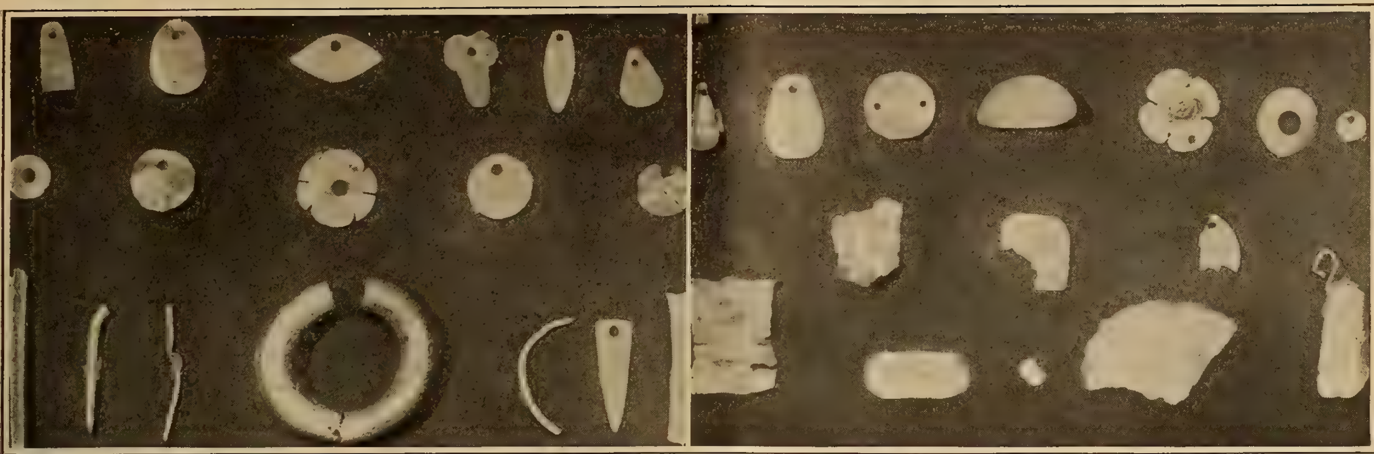
MOLYBDENUM STEELS

In the March 2nd issue of *Chemical and Metallurgical Engineering* there appears an interesting discussion of molybdenum steels by Dr. John A. Matthews from which the following is quoted:

Molybdenum, particularly in conjunction with chromium, seems to confer the property of deep hardening. This is to be expected from the observation that molybdenum steels resist the drawing temperature to quite an unusual degree. In other words, they require a higher drawing temperature to reduce the physical properties by the same amount that they would be reduced in similar steels without the presence of molybdenum. This indicates that molybdenum tends to keep the carbon in steel in the combined or martensitic form, and when in that condition to retard its passage to the sorbitic or troostitic state. Some years ago the writer sent to Prof. H. C. H. Carpenter, then at the National Physical Laboratory of Great Britain, a chrome-molybdenum steel together with a variety of commercial high-speed steels for use in his investigations upon the drawing or softening of hardened high-speed steels. This particular steel contained but 4 per cent of molybdenum, 3 per cent of chromium, and about 0.47 per cent carbon, yet it resisted the draw-back temperature, as measured by Professor Carpenter's etching method, to a greater extent than any of the commercial tungsten high-speed steels used by him, whether of American or British manufacture.

It is possibly too early to make predictions, but the writer believes that molybdenum has established for itself a permanent place among the alloy steels found useful to the airplane, automobile and general engineering trades. It will not wholly displace any other type of steel, but the effect of improvements of this kind and new products has been rather to extend the field of usefulness than to eliminate products of previously demonstrated merit. The bessemer and open-hearth processes, and the electric furnace have not displaced the original crucible cast steel business. The demand for steels made by each method has arisen with the process itself.

Not only does molybdenum below 1 per cent give no trouble from volatilization, but it may be recovered from scrap when remelted in the open-hearth furnace to a large extent.



Courtesy Amer. Mus. Nat. Hist.

EARLY ORNAMENTS OF GOLD AND PLATINUM FROM ECUADOR

The Romance of Platinum

Recently Discovered Fields Which Yield this Most Precious Metal

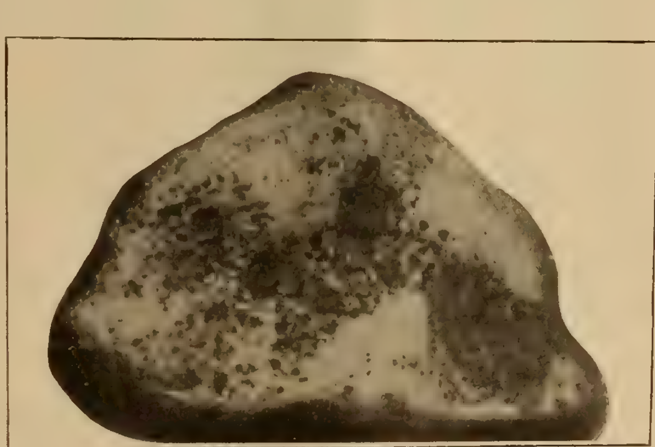
By Charles Henry Dorr

PLATINUM, one of the world's most precious metals, has an interesting history. It has eclipsed gold and silver in value and rivals ornamental gems, and in fact is only exceeded by the related metals, iridium and ruthenium, which are now worth considerably more.

During the Great War the use of platinum for catalyzing purposes in the production of concentrated sulphuric acid for the making of explosives, for dehydrating nitric acid, for airplanes and other war machines brought this metal into prominence. It is one of the two metals that possess at once malleability and ductility, and are not attacked by acids, namely, gold and platinum.

The wonderful ductility of platinum is realized when it is considered that a single troy ounce of the metal could be transformed into an almost infinitely slender wire that would reach from Santiago, Chile, across the continent to Rio de Janeiro, a distance of about 1,800 miles. To draw out platinum into such a fine wire it is necessary to cover it with a thin layer of gold. Such a slender wire would be practically invisible.

In the golden days of 1849 miners and adventurers were rushing to the gold fields of California in quest of fortune in the new Eldorado of the West. Gold was the magnet for the miner of that day.



Courtesy Geo. F. Kunz

SPECIMEN OF PLATINUM FROM COLOMBIA

Today the world's great treasure hunt is for platinum now worth about four times as much as gold, although its value has soared to as high as seven times its equivalent in gold. The almost universal demand for this precious metal has caused a world-wide search for it in the Ural Mountains of Russia where rich deposits of platinum exist, in the waters of the Condolo, Atrato and Choco Rivers of Colombia, and even in Alaska and the Arctic regions.

A new field of platinum has also been discovered in Spain along the banks of the Verde River and in the Ronda Mountains. Traces of this valuable metal have also been found in Australia, South Africa and Mexico.

There is not much question about the wide distribution of this precious metal, for it is found in almost all parts of the world, and while preceding the war Russia supplied 95 per cent of the production of platinum, later on it developed that much of this widely-sought treasure existed in Colombia, and this new field promises to yield much of the anticipated supply of the valuable metal in the near future.

It is singular that European knowledge of this wonderful metal dates back only about two centuries, although ornaments have been found in the pre-historic graves of Ecuador dating back some two thousand years ago, with traces of gold and platinum.

FIRST PRINTED MENTION OF PLATINUM

Perhaps the first printed mention of platinum may be noted in the title page of the book printed in Spanish, "Relacion Historica del Viage A La America Meridional," with Madrid imprint, the first volume of the account written by Don Jorge Juan and Don Antonio de Ulloa of their journey to South America in 1735, with the French expedition, to measure a degree of the meridian for the determination of the true figure and the magnitude of the earth. This work was published in 1748, and in it appears a mention of the metal platinum. It is here called "a stone of such resistance that it cannot easily be broken or reduced in size by a blow on a steel anvil."

For several years Dr. George Frederic Kunz, author of "The Book of Pearls," and widely known as a connoisseur of gems and precious stones, has been making an exhaustive study of platinum, and through his courtesy I am enabled to present the latest and most interesting developments concerning this wonderful metal called by some chemists "white gold," and including references in reports on platinum in Latin America, and information as to its production.

"It is indeed difficult to realize at present that in the first half of the past century," says Dr. Kunz, "after the discovery of platinum in the Urals, the Russian Government issued a platinum coinage, the intrinsic value of the coins being reckoned as less than six times that of silver and only a little more than one-third that of gold.

"The Russian platinum coinage, begun in 1828, in the reign of Nicholas I, consisted of 3-ruble, 6-ruble and 12-ruble pieces, worth at par $2.40, $4.80 and $9.60, according to the value of the ruble at that time; the coins contained about 2 per cent of iridium. The nominal worth of these coins was about $3,000,000, but the metal in them would now bring nearly $50,000,000."

It is interesting to note that as a precursor of the legal Russian coinage of platinum, certain Spaniards engaged in a counterfeit coinage of Spanish doubloons (gold coins worth about $8.24 from 1730 to 1772). Describing the process, Dr. Kunz says: "A piece of the same size was struck in platinum and the surface was then gilded as the specific gravity of the only partially refined platinum was approximately that of gold, so these spurious pieces could be circulated without much difficulty. In our day such a counterfeit doubloon would be worth intrinsically about $40.

"The Swedish chemist, Henry Theophilus Scheffer (1710-1759), is said to have been the first to call platinum 'white gold.' He says that its nature most closely approaches that of gold, so that it may justly be called 'white gold.'

"It was only in 1783 that a veritable platinum ingot was made by a European chemist. The honor of this accomplishment belongs to the French chemist, Chabaneau (1754-1842), who gained such a high reputation that the reigning Spanish sovereign, Charles III, called him to Madrid and created for him a special chair of mineralogy, physics and chemistry. He was given lodging in a palace and an annual stipend equivalent to $2,200."

EARLY ORNAMENTS FROM ECUADOR

"What are believed to be the oldest ornamental objects made of platinum were excavated in the province of Esmeraldas, Ecuador, by Mr. D. C. Stapleton. Most of these ornaments are made of gold and platinum combined, one or two thin layers of the latter having been hammered on to a thin layer of gold. They are thought to date back 2,000 years at least. Similar objects have been found in prehistoric graves in the Island of Tola, at the mouth of the Santiago River, Ecuador. These relics are now in the Museum of the American Indian, New York City." However these relics are not at present on exhibition but, with other specimens of precious metals, are reposing in a safe deposit vault, awaiting the installation of the collections in the Museum, which will be opened in the fall.

The American Museum of Natural History has in its collections some interesting examples of early ornaments of gold and platinum from Ecuador and presumably of the same period as the specimens in possession of the Museum of the American Indian. Through the courtesy of the American Museum of Natural History a reproduction is offered of these prehistoric ornaments, found on an island in the Santiago River, Ecuador.

It is the belief of Dr. Kunz that Spain was probably the first country to receive information in regard to platinum, and he says: "It was probably the first to receive specimens of the new metal, although the printed and dated records might seem to give the priority to England. It is perhaps something more than a coincidence that it was on Spanish soil that platinum was first discovered in Europe. The initial discovery was made at Guadalcanal in the province of Estramadura. Here it occurred in some gray silver ores."

Courtesy Geo. F. Kunz

WASHING FOR PLATINUM IN THE STREETS OF QUIBDO, COLOMBIA

NEW FIELDS IN SPAIN

Evidently there is a revival in prospecting for platinum in Spain for promising new fields have been located in the Ronda Mountains, near the coast, and about half way between Malaga and Gibraltar. It is reported that platinum has been found along the River Verde where much preparatory work has been completed by the prospectors seeking this precious metal, and work is also under way at Guadaiza.

According to reports from Spain the tract along the Guadaiza appears to be richer in platinum than that of the Verde region. The method followed has been to dig holes at intervals of two hundred meters and make soundings every twenty meters between each hole. It is stated that the provisions of law enacted by the Spanish Government several years ago closed the Ronda region to public search for platinum, with reservations for state rights in exploiting or prospecting.

The conditions of the platinum deposits of the Sierra de Ronda in Spain have been compared by Professor Louis Duparc with those of the famous Ural district in Russia with interesting results. He has arrived at the conclusion that three primary platiniferous deposits exist: "The dunite type of rocks, the most usual form, and also the richest; the pyroxenite type, rich in magnetite, and a form more rare than the preceding one, and the peridotite containing rhombic pyroxene in greater or lesser quantity."

Commenting on Professor Duparc's report, Dr. Kunz says: "The data as to deposits of this nature are still too insufficient to permit us to arrive at any justifiable conclusion as to their richness."

PLATINUM IN RUSSIA

Russia is the great Eldorado for seekers of the "white gold," and immense quantities of this highly valued metal are known to exist in the region of the Ural Mountains where many of the finest specimens have been located.

The Russian production of platinum averaged before the war 95 per cent of the world's supply and since the outbreak of the war no complete statistics have been available.

Platinum was first discovered in the gold mines of Dakovlov, in the Ural Mountains, Russia, in the sands of Naviansk, Bilimbayensk, in 1822, and in the Kurshinsk works in 1824. In 1825 the richest Uralian deposits were discovered. They were the sands of the Sucho-Vissimsk works in the district of Nizhni-Taglisk.

Daubrée discovered, in specimens of the country rocks from the mines of the Tagilsk region, platinum in association with olivine, serpentine and chromic iron. In this famous platinum region the largest nugget in the world was discovered; it weighs 23.5 funts or 9,628.88 grams (25 pounds, 9.45 ounces troy). This specimen is known as the great Demidov platinum nugget, and its dimensions are 7 by 4 by 3 inches. The value of this remarkable nugget is given by Dr. Kunz at about $25,000, although it must have been worth more when

quotations for platinum were higher than present ruling prices.

In January, 1834, there was found at Martinov, where platinum was first discovered in the Urals, a slightly smaller nugget, weighing some twenty funts (21 pounds, 4 troy ounces, or 8,335 grams).

Juan Makarovich Belov in quest of gold in the Domidov mines of the Nizhni-Tagilsk region in 1825, discovered platinum. He found only a small amount of gold, but considerable of another metal, which upon being tested proved to be platinum. His discovery led to an extensive exploitation of this field, and by July, 1840, some twenty-one mines had been opened.

Perhaps the richest platinum sands are those of the Iss River, which flows through the eastern slope of the Urals from its source, and then follows a winding course for some thirty miles to the point where it merges into the waters of the Tura. Another tributary of the Tura, the Veeya is also said to be rich in platinum.

Courtesy Geo. F. Kunz
DREDGING FOR PLATINUM IN A SOUTH AMERICAN RIVER
Capacity of dredge, 400,000 cubic yards

The largest part of the Russian output of platinum since 1879 has come from the area of the Tura Valley, but before this date the Nizhni-Tagilsk region, more than one hundred miles to the southward, proved the most productive.

WEALTH OF TREASURE IN PETROGRAD

It is rather an interesting question as to what degree of success will attend the efforts of financiers to issue Russian currency notes secured by the stock of platinum in Russia. Cable dispatches have indicated a plan to issue notes of 50, 100, 500 and 5,000 rubles, the basis being an accumulated stock of platinum worth 37,500,000 gold rubles, equivalent to $19,290,000. The issue is to be limited to 65,000,000 rubles.

Some idea of the amount of gold and platinum in Petrograd when Lenine took command is gained through the statement that in November, 1917, there were in the vaults of the State Bank there more than $200,000,000 of gold in bars, and 25,227 troy ounces of platinum, 96 per cent pure, worth at the then ruling price of $104 a troy ounce, over $2,600,000.

There was a sale of platinum in Russia in March, 1919, under the control of the Omsk Government in Siberia. By its decree all producers were required to sell to the Government the entire quantity of the crude metal recovered by them. After the supposed value had been computed the producers were given half of the amount in Russian paper rubles, and the other half was only paid over (also in currency) after the metal had been disposed of by the State Bank.

It is the opinion of C. W. Purington, who has written a series of articles published in the *Echo*, that if the Iss platinum fields in the Urals were intensively worked by modern dredges it would yield an annual output for ten years of perhaps 300,000 ounces of the metal, but would then be exhausted.

However, other fields give promise of more inexhaustible supplies of this valuable metal, for as Dr. Kunz finds: "Owing to a variety of considerations, the Nicolai-Pavda region in Russia on the Kytlim River, and on the Lobva River below the place where it is joined by the Kytlim, seems to afford better prospects of good future results in platinum mining than any other known fields."

Prospecting work was begun in this tract in 1912-1913, although it had already been extensively worked by hand labor, and the forecast pointed to the existence of 26,000,000 yards of placer platinum ground, indicating prospective returns of over $8,000,000 for the exploiters. Just before the war these placers occupied the third position among the platiniferous areas of Russia, and as many as 5,000 men were employed there in the summer season.

Not much has been known in the United States of the company which was eventually formed to exploit these placers under the title of the "Nicolai-Pavda Mining Co.," for it was financed by the Anglo Russian Bank, and the shares were mostly dealt in on the exchanges of Paris and Petrograd.

The price of platinum has of course risen rapidly since the war, in Russia, as elsewhere, so that in 1918 the Nicolai-Pavda Co. increased its dividends to 8,000,000 rubles. As Russian exchange had not yet reached its present abysmal depth at that date, this means a larger sum of "real money" than it would today.

As to the platinum deposits of the Nicolai-Pavda region, Professor Duparc states that, of the three platiniferous centers, the most important is unquestionably that embracing the rich alluvial deposits of the Kytlim and the Lobva Rivers, those of the former having been partially worked, while those of the latter remain untouched.

Courtesy Geo. F. Kunz
ANOTHER DREDGE IN THE PLATINUM COUNTRY
Capacity of dredge, 1,000,000 cubic yards

As Russia will probably continue to yield the largest supply of platinum in the future as this country has in the past, the merger of the Russian Economic League with the American Chamber of Commerce is of interest to those in need of the valuable metal.

The League has already accomplished much in bringing American and Russian business men into contact. Hon. William C. Redfield, formerly U. S. Secretary of Commerce, is president of the American-Russian Chamber of Commerce, which includes a number of other representative men.

PLATINUM FIELDS IN COLOMBIA

For several years attention has been directed to the platinum deposits of Colombia, and according to Dr. Tulio Ospina, director of the School of Mines at Medellin, Colombia, a vast area of over 5,000 square miles exists containing gold and platinum in the region lying west of the central ridge of the Colombian Andes, in the drainage basin of the Atrato and San Juan Rivers, and extending south of the latter to the Mira River. It is stated that a much larger proportion of platinum to gold is found in the gravels of the San Juan River than in those of the Atrato, the two metals occurring in about equal quantity in the former, while in the latter the proportion is about 35 per cent of gold to 15 per cent platinum.

The most productive area is controlled by English and American capital, and the formation of a United States of Colombia Exploration Corporation with considerable capital is of importance, for it is predicted that it is to Colombia that we must look for most of the supply of platinum during the present year.

A dredge has been operated on the Rio Condolo in Colombia with successful results and others are projected for use in this region.

The Republic of Colombia has laid a tax of 5 per cent ad valorem upon all platinum exported from that country after June 15, 1915, and it is anticipated that if the increased supply of platinum materializes in the Colombian mines the treasury of that Republic will be considerably enriched.

It may be of interest to note the increase in the importations of platinum from Colombia to the United States for a period of say eight years. In 1910 for instance, the value of platinum imported from Colombia to the United States was $31,383, and for the fiscal year ending in June, 1913, the importation of this metal had increased to the substantial sum of $2,241,744.

So Colombia promises to be a rich platinum field in the future.

Referring to the production of platinum in Colombia the Pan-American Union composed of twenty-one American republics states: "Colombia produces an average of 30,000 troy ounces of platinum a year, practically all coming from the Quibdo district.

"The high prices prevailing during the war greatly stimulated the production of this important metal, and entire districts along the coast and rivers west of Cartagena were depopulated, the people emigrating to the platinum district to wash for platinum gold.

"The Atrato and Choco Rivers are tributary to Cartagena commercially. Therefore merchants in Cartagena are the heaviest buyers of platinum and gold from the placers of these rivers and also supply the merchandise needs of the region through their agencies established in Quibdo, Istmina, and Baudo. The development of water transportation of the San Juan River has taken some of the trade away from Cartagena, and the district has also been invaded from Medellin by traders from Antioquia. During the war the United States took almost the entire platinum output of Colombia."

TOWN TURNED INTO A MINE

The rejection of platinum as waste in the operation of refining gold was the cause of some odd incidents in Colombia. When platinum became valuable a considerable quantity was discovered in Quibdo, capital of the Choco district, where much gold refining took place, and as a result the entire town of some 1,500 inhabitants was transformed into a mine. Property owners mined under their houses, and tore down their buildings in their quest for the hidden treasure. One merchant was not only enabled to rebuild through platinum mining, but also cleared $4,000 in American gold. Some of the platinum separated from gold by the dry or "blowing" system was wafted into the streets or the cracks of buildings.

Colombia probably ranks second in the world's production of platinum, although far behind Russia in the output of this precious metal. There is a prospect, however, that Colombia may overtake Russia some day, and take first place as the richest platinum region in the world.

PLATINUM FIELDS IN ALASKA

A bill was introduced in Congress in September, 1919, for the incorporation of the "United States Platinum Corporation and to aid in the development of the mineral resources of Alaska and for other purposes," which would indicate that vast fields of platinum exist in that country. The capital stock was not to exceed $50,000,000, and it was to be exempt from Federal taxation, and empowered to receive concessions and leases of government-owned platinum sands in Alaska. Prospecting has been carried on in two localities in Alaska for platinum, one of these on a tributary of the Kahilna River, and the other several miles below the mouth of Peter's Creek.

Although it is not generally known when Captain Joseph E. Bernier, a noted explorer, returned from his last expedition to the Arctic regions, he announced to the writer that he had located some important "finds" of platinum in the Far North. He did not describe the exact locality of these fields, but they are known to exist and probably will be exploited in the future. Thus far Canada has not produced any great quantities of platinum.

SUBSTITUTES FOR PLATINUM

The need for a satisfactory substitute for platinum is making itself more and more urgently felt. For certain uses an alloy of nickel and iron may take the place of platinum. This alloy, to which the name of "platinite" has been given may be used in incandescent lamps. Nickel-chromium is sufficiently resistant to chemical action to render it a fairly good substitute for platinum in the laboratory. Cobalt is even better than nickel when in contact with strong acids. The low melting point of gold makes that metal unsuitable for some purposes, but this point may be raised by the addition of palladium. This alloy, called "palau," from the Latin name of its component elements, has been tested by the Bureau of Standards at Washington and found to be superior to platinum in some respects, though inferior in others.

FUTURE FUEL

Dr. J. Howard Mathews of the University of Wisconsin in discussing probable sources of future fuel before the Chicago section of the American Chemical Society emphasized the importance of photo-chemistry and the possibility of perhaps some day finding a catalytic agent which would make it possible to combine water and carbon dioxide to form a carbohydrate from which alcohol might be produced.

"With constantly diminishing reserves of fuel," said Dr. Mathews, "the question of the utilization of the radiant energy from the sun becomes more and more of a live question. What will the world do when fuel is gone? Such a possibility is, at least geologically speaking, a question of the almost immediate future. Hundreds of millions of horsepower of energy are coming continuously from the sun. How can this energy be stored up and transformed into a useful form of force? The optimistic photo-chemist believes that it can be employed to bring about certain chemical reactions, which, by their reversal, will again liberate it, preferably in the form of electricity. The dream is no more chimerical than was that vision of a hundred years ago, in which electricity was conceived as stored and utilized."

Chlorophyll, which imparts the green color to leaves, is believed to be a sort of catalyst which in sun light enables the combination of water and carbonic acid gas to go on forming the starches and sugars of plants. The present task of the photo-chemist is to study all possible types of reactions produced by all kinds of radiation, for in no other way can a thorough knowledge of the laws and principles involved be gained.

When these laws are understood the future may give us many important practical applications.

GUIDE AND CLIMBERS PROPERLY ROPED ON THE "EISMEER." THE ROCK GALLERIES OF THE EISMEER STATION OF THE JUNGFRAU RAILWAY ARE SHOWN ON THE LEFT

"Mountain Craft"

Personal Regimen, Walking Manners and Equipment for the Climb

Reviewed by A. A. Hopkins

Fellow of the American Geographical Society

IT was not until after the war that a number of books on "Mountain Climbing" appeared, as of course an amusement of this kind could hardly be indulged in during the stern war period, although mountain climbing is often productive of extremely scientific results. A mountaineer is not only one who climbs mountains, but one who likes to walk, read or think about them. As in any other sport book-learning is of limited value, but there are certain fundamental facts which are of service, that can be learned from books. We have just had the privilege of examining a recent work on the subject, "Mountain Craft," by Geoffrey Winthrop Young.* The present article will be regardel to some extent as a review of this book plus such information as is now obtainable as a result of correspondence with Swiss authorities. The whole subject is very interesting in view of the projected ascent of Mt. Everest, the tallest mountain in the world.

The advice which Mr. Young gives is admirably supplemented by chapters by specialists. Mountaineering, in its wider aspects, can only be learned by experiment, and even the natural climber may be able to get some guidance from the collective expression of other men's mountaineering experience. Many efficient climbers, again, never bother themselves at all with mountaineering as a craft. They simply take its pleasures and leave its responsibilities to guides or to chance. Most of us are, in a sense, specialists: interested in one department alone, and neglectful or ignorant of the rest. For such of us there is some benefit in surveying, if only superficially, the immense field that a man must set himself to traverse who aspires to lead a party safely.

*Published in U. S. by Charles Scribner's Sons, New York.

A party consists usually of from two to four climbers, exclusive of guides. A larger number inevitably divides into two or more units for mountaineering purposes. The management devolves upon the most experienced mountaineer. His selection as leader, in this sense, is more often than not tacit and unexpressed, especially among British climbers. Over-management is fatal to the effective coöperation of a party: and a formal selection of a leader, or a precise insistence upon the performance of particular duties by individual members may only disturb the pleasant relationship of friends on a climbing holiday. If a man is not felt to be qualified as leader by personality and experience no vote will make him so. If it is the duty of the young mountaineer to learn to accept a constitutional authority for the good of his party, it is that of the leader or manager to see that it is used only for the good of the party and to make it personally the less obvious, the more it grows to be accepted in understanding.

PERSONAL REGIMEN

There is no need to bother overmuch about the party before the tour commences. Of course men, for their own sakes, will come as fit as they can. Attention to the diet and, if it can be got, some regular exercise in the open air, such as walking, running or tennis, but the author has never seen any particular benefit accrue from exercising particular sets of climbing muscles. The first few days of the tour, however, are vital. Mountaineers are sound men, and have usually only two weak points, the feet and the stomach. New boots or overwork attack the first; unaccustomed food, chang-

ing atmospheric pressures, and revolutionary hours of sleep, food and exercise upset the second. For the feet precautionary measures are the safest. In ordinary life we accept their constant service unconsciously, and it requires an effort to give our own, and even more, other men's feet the additional attention they require on the first few days of any tour. To see that the boots fit, on the second day even more than on the first; to make sure that one or even two extra pairs of socks are put on if any boot has become stretched after wetting; to discover if there is any beginning of rub or blister, and to check it by boracic acid powder or ointment in the sock at once, even if this means a halt in the middle of the climb; to suggest bracing with cold water in the evenings or whenever opportunity offers, in the case of anyone whose skin is tender; to double these precautions—these are some of the first duties of management.

Internal chill is a constant risk during the first few days of exposure to unaccustomed changes of temperature. Damp clothes next to the skin are principally to be avoided. A spare vest or a flannel shirt should always be taken in the sack, for a change at hut or bivouac, even if the other clothes have to be worn wet or slept in. In a hut it is preferable to take the wet clothes off and to sleep rolled in a blanket, even though that may be also damp. During the day it is unwise to sit on damp or cold rocks. A coil of rope may be used as a seat, or a useful habit is to carry a small square of waterproof, in which the spare shirt can also be wrapped. When nearing the hut it is well to reverse the usual practice and go slow for the last twenty minutes, so that the perspiration may dry gradually from the body while in motion, and not after it is at rest. By the fire in the evening, during the snooze on the summit, and especially in an enforced bivouac, the stomach is the vital point to protect. In case we get benighted any spare clothes or even paper should be wrapped round the stomach. The coat should be taken off and fastened round the shoulders outside the arms, so as to concentrate all the body's warmth within it. The feet can be put in a rucksack. If possible, the boots should be kept on, to avoid their freezing hard. If they have to come off so as to save the feet from frost-bite, they should be sat upon, to keep them soft. Wind is another enemy to guard against while resting during the day or sleeping out, and a light wind-cloak is a sound protection. On returning to the hotel, a hot bath, if procurable, or a hot sponge-down, should always be taken; it not only clears the pores and supples the muscles, but it restores the normal circulation and removes congestion, due to great exertion and changing temperatures, which often produces a general feeling of discomfort, especially in the head.

FOOD AND DRINK

Care in the choice of food, discouragement of the inclination to starve during the day and to overeat in the evenings, insistence upon a regimen to new time-table, and, in case of failure, the employment of the simple domestic remedies at once and in time, these are all indispensable during the first days. In the matter of the choice of food the leader has to overcome the repugnance natural after a satisfying evening meal to attend himself to all the rather messy details of provisioning for the next day. No guide or hotel-keeper can be trusted to do this. During the first days of hard exercise the average man will eat but little food, and turns from meats and tinned goods such as hotels love to load into the sacks. He has to be tempted with sweetstuffs, jams, chocolate, and meat-essences and eggs for support. The disposition to eat little during the effort of the first days and to eat largely in the reaction of the evenings, has to be countermined by the offer, at not infrequent intervals, of pleasant luxuries that go down easily. It is old-fashioned and entirely wrong, especially with young people, to give them only what used to be termed wholesome, nourishing food. In healthy open-air conditions the body knows what it wants, and the palate interprets the desire. Food that is not palatable or eaten with pleasure is of little benefit, and cloying sugar compounds, the best muscle fuel, become again surprisingly attractive.

Thirst is another difficulty at the beginning of a tour. To a large extent such thirst is merely feverish; it is impossible of satisfaction, and to indulge it swamps and upsets the human machinery. Some resolute men, to avoid the delicious temptation, train themselves not to drink at all during the day, and then make it up in the evening. But a certain amount of liquid is as essential, in action, as a certain amount of food, and the moderate habit has to be acquired by practice. The exact amount necessary, as distinguished from acceptable, varies with the individual. The merely feverish thirst of the first day can be dodged by letting water run through the mouth, swallowing, as a special indulgence, only a mouthful or so. Sucking a prune-stone or even a pebble, keeps the saliva flowing and is a consolation on hot snowy tramps. To the same end, of prolonging the pleasant assuaging process, devices such as sipping water slowly from a pearl-shell or cup cool

SNOW WORK—THE JUNGFRAUJOCH DISTRICT, SWITZERLAND

to the eye, chewing orange peel, sucking a lemon or tea slowly through lumps of sugar, or crushing a handful of snow till it becomes an ice-pear in the hand and then sucking the end of it, are all worth remembering.

WALKING MANNERS

There are several points of what may be termed "walking manners," common to all types of long mountain walking and not only to climbing, whose observance contributes a great deal to the individual peace of mind during the early and late hours of a long alpine day. Men when they are off the rope, or who have never been on a rope, almost universally neglect them, and are blind to the cumulative effect upon a tired companion's temper or upon their own humor.

The first point of manners for the man in control is that of pace. Most climbers suffer from the weakness of increasing the pace the moment they take the lead on a path, slope or glacier. This is trying to the party, consciously or not, and wasteful. A manager should either block the way himself, or, if he is behind, keep consistently to what he considers the right tempo.

A second and frequent failing is the "half step" trick. Some fifty per cent of fast walkers, whenever they walk abreast on road or path or hill, persistently keep half a stride in front, their shoulder just clear of their companion. It may be due to some half-formed feeling of satisfaction in setting

the pace and having a margin to turn round and talk from. Its effect is that the friend is perpetually straining to catch up, and the pace thus steadily accelerates till both are practically racing. Then one gives up, and both lag until the game starts again.

A third breach of manners, all too common, is passing ahead in the line of march. Over most broken country, glacier, snow or rough hillsides men naturally fall into single file. Cattle tracks or man tracks are rarely wide enough for two abreast, and if it is a question of selecting a line, it saves reduplication of the effort to leave the task to one and to drop in behind him. There are few inexperienced walkers who do not take advantage of the slightest error in the choice of route on the first man's part, to break off and pass him on the shorter line. In doing so they take the responsibility of taking all the rest who follow, off the line also. On an ordinary hill walk, when the going is all free and easy, this is excusable. But, done as by one of a line of men either tired or with a big day before them, where one has been taking the extra burden of route-selecting for the rest, it is a serious breach of mountain manners.

A more debatable occasion, where the same point comes into

CAPTAIN FINCH WHO WILL TRY TO WREST THE SUPREMACY IN MOUNTAIN CLIMBING BY THE SCALING OF MOUNT EVEREST, REPAIRING HIS CLIMBING BOOTS

prominence, is on the ascent of steep slopes or open hillsides. An experienced front man will probably take these on a zigzag. To a less experienced walker, and to all beginners of energy and leg muscle, it is generally a temptation to cut the zigzags on the direct line, and so pass ahead. This is bad walking, but there is the more excuse for it in that on such slopes men rarely do follow each other exactly and most of the party will probably be preferring each to take his zigzag at the most comfortable angle to himself. The best rule of manners to remember is that, while every man is free to choose any line and pace he likes on such places, yet, if one man has been definitely leading and choosing the line, the others ought to drop into their places in the line behind him again so soon as the single-file formation is resumed.

Another blunder, from which many a good walker is not free, is the inclination to hurry the pace if the line or short-cut he has chosen takes the party for a while over worse ground, or proves, for other reasons, not to have been the best route. His almost unconscious acceleration is due to some impulse to get back quickly and unnoticed to good going, and so to slur over the mistake, or the momentary disagreeability of the route for which he is responsible, as much to himself as to those who follow. It is a trick to notice and avoid. It forces the rhythm and pace over just the ground where it should, if anything, be eased.

Again, when walking in single file, or any way but comfortably abreast, men inexpert in acting as guides do not realize that although the man in front can hear all that is said behind him, yet that, unless he turns his head over his shoulder and throws his words out, he himself is inaudible down the line behind him. As the remarks from the leader on a long tramp, and when men are tired, have usually some direct bearing on the way, those behind him crowd up to hear; they break step and are often put irritably on the strain. These matters may seem too slight to mention, but neglect of their observance brings many a party home with some member or other out of harmony and unappreciative of the sunset.

THE WEATHER

There is one variable which belongs to the mountaineering rather than to the human division of the problems with which management has to deal. The weather is the background, foreground and middle distance of all big mountaineering. A change can upset the nicest adjustment of a climb to the strength of a party or to the length of a day. Every climber keeps one eye on this irresponsible neutral, which may at any time turn the scale of the campaign against him. The scientific study of weather, and its prediction by the barometer and thermometer, are matters for a whole book, and the authoritative text-books are available. Instruments larger than of pocket size are something of an encumbrance to a climbing party.

Even more than the clouds, once we have discovered the habit of the year and the local signs, the winds are our firm basis for forecast. The north wind in the Alps is usually for good, though in a bad season of habit it may, if long continued, bring snow. The south wind is always fraught with suspicion, until it justifies it. It brings a succession of storms, but leaves fine intervals. The west wind, if continuous, means the continuance of unsettled weather, with an inclination to preserve whatever may be the habit of the year. It is perhaps the most forcible and trying of winds to encounter on the ridges exposed to it. The east wind is infrequent and rarely long continued. Its portent is favorable. The southwest wind means rain to follow. A change from north to northwest threatens rain. A change from southwest to northwest—generally a wind on its way to becoming a north wind—means a change for the better in bad seasons. Southeast, and especially northeast, winds share the good qualities and projects of the east wind.

A red sunrise is bad; a red sunset good. Sunrise on a gray sky means a fair day; sunset on a gray or pale yellow sky means a rainy day, on a bright yellow sky a windy day.

A "high dawn," the sun showing first over a vapor belt, is an ill sign; a "low dawn," the sun leaping from the horizon, a good sign.

If the distant sky at dawn, especially to the west, is low and dark, there will be breaking weather by noon.

A dark blue sky tells of wind and probably rain to follow; a light blue sky is of fair weather.

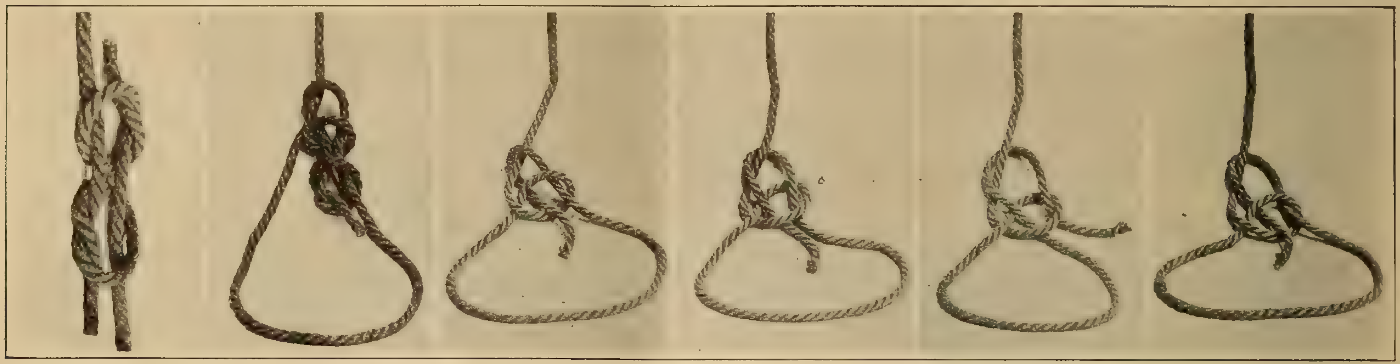
All over bright or gaudy colors at sunrise or suset, and all hard outlines, foretell rain and wind. Delicate colors, well-blended tones and filmy cloud edges are fine weather prophets.

Rings around the sun or moon, and vivid twinkling stars in the later night are bad signs. Clear nights of cold, and calm and quiet stars before dawn are good.

Heavy dews and the falling of the wind at sunset are good signs.

The clearness and nearness of distant hills, except just after rain, is a bad sign; but there we may distinguish between a clear landscape when we face toward the sun, which is an ill sign, and a clear landscape as we stand with our back to the sun, which is quite usually a fair sign.

Ascending mists on hillsides are bad. Mists in valleys at



FIGS. 1-12. CORRECT AND INCORRECT METHODS OF TYING SOME MOUNTAINEER'S KNOTS

Left to right, upper row; 1, Thumb knot, correct; 2, same, incorrect; 3. Figure of 8 knot, correct; 4. Figure of 8 tie, correct; 5. Single fisherman's bend, correct; 6. Same, incorrect. *Lower row.* 7. Single fisherman's bend, incorrect; 8. Bowline and overhand knot, correct; 9. Bowline, correct; 10-12. Incorrect forms of bowline knot

evening, clouds lifting at sunset, and hilltops smoking their pipe of evening peace, are good.

Warm airs as we pass up the lower alps or through the pinewoods mean us well; but warm nights on the height and in the hut, or the sickly puffs of warm breath that meet us from the large crevasses as we start up the glacier before dawn, are omens of ill weather.

Early rain, "rain before seven," has no serious meaning; it rarely lasts.

Early white mists should never frighten us from starting, but we must judge them by feel, texture and direction of movement. An early ominous mist has a different quality, and lies differently from a simple mist of the hour.

MOUNTAIN CLOTHING

The second chapter of Mr. Young's book deals with equipment for the Alps and is written by Capt. J. P. Farrar, and forms one of the most interesting sections of the book. Too much attention cannot be paid to the question of equipment and Captain Farrar's recommendations are based on the experience of a great many years' active service in mountaineering. He recommends very stout cowhide, unlined boots, worked to the softness of thick buckskin. He says very justly that the ordinary boot maker knows nothing about the alpine boot and those who are thinking of extensive mountain excursions should consult those who make a specialty of outfits for mountain climbing. An unlined boot will dry very quickly if stuffed with dry paper, hay, straw, or oats and will be very supple if treated with a little castor oil before each expedition. Captain Farrar goes into the question of nails in considerable detail. These nails of course can only be obtained from dealers in alpine supplies and can easily be secured in Switzerland. He specifically recommends the "Tricouni" nail, which we illustrate. These are set close to the edge of the sole and continue right up to the heel. These nails can be used for the tread of the soles, or almost preferably half a dozen wrought-iron hobnails suitably spaced. The plates protect the sole and give a firmer stand than the ordinary nail. Captain Finch's shoes are a good example of a well-protected sole. Captain Farrar recommends a soft sock of Norwegian natural wool which can be obtained from alpine centers or in London.

A coat of stout tweed is recommended, especially those which are made shower proof. He specially objects to lining, except to protect the outside of the arm from the shoulder to the elbow. The buttons should be closer than usual, so as to keep out the driving snow. The idea is that an unlined coat will dry far quicker than a lined coat. Knickerbockers of the same cloth are recommended. A light woolen sweater and a light woolen muffler about one foot wide and six feet long is recommended, especially for very cold weather, or for sleeping out, when it can be tied twice around the stomach and fastened with safety pins. A light water proof cape of Japanese silk can be procured, which weighs only about one-half pound. Long gloves are also recommended. A tam-o'-shanter is approved in place of a cap.

EQUIPMENT FOR THE CLIMB

The outfit should be carried in a "rucksack," which can be obtained from all sport outfitters. The question of ice-axes is an important one and there are innumerable types supplied by alpine outfitters; an approved type should be used, and the axe should weigh about three pounds. We give two examples of ice-axes selected from various sources.

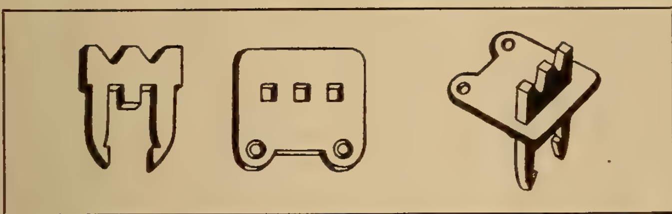
The question of rope is a most important one and flax rope seems to be preferable. Such rope can be secured in London or in climbing centers. What is known as "left-hand" alpine rope is recommended by Captain Farrar, and we have been able to examine samples of it through the courtesy of London climbing outfitters. It is beautifully flexible to handle and knot, and after the first wetting, shows no tendency to kink. The author in this chapter makes very pertinent suggestions relative to rope in connection with mountain climbers. He says for haulage of "duffers," where the rope is constantly dragged against rocks, no doubt a much heavier rope of Manila, or possibly "wire rope" would be preferable. The rope should not show undue wear during a single season. Captain Farrar never uses rope a second season for life may depend on its strength and a new one can be purchased for a few shillings. Even when the rope shows no appreciable wear, it may have been subjected to some sudden severe strain which has robbed it of a portion of its virtue. Captain Farrar says that used ropes ought not to be given away to guides who

will go on using them for an indefinite time. This is good advice.

With respect to knots for use in alpine ropes, Mr. Eckenstein was again good enough, says Captain Farrar, to investigate the question, and the accompanying illustrations have been prepared from photographs taken under his instructions. They are all applicable to a "left-hand" rope.

The following is an extract from his letter to Captain Farrar:

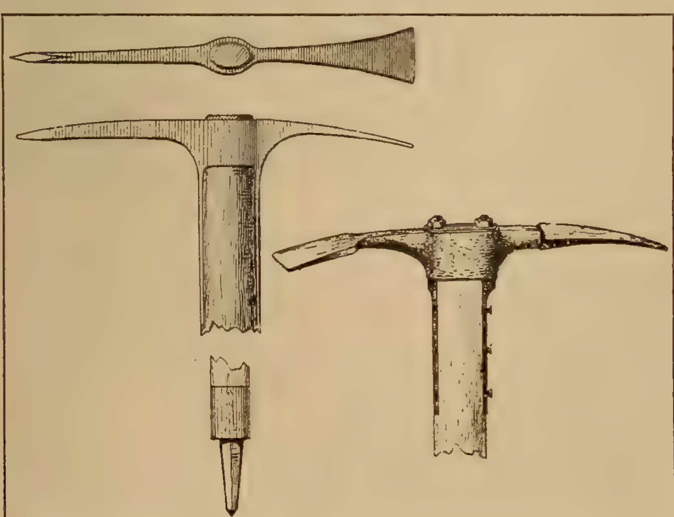
"A laid rope usually consists of three strands twisted together. Each strand thus forms a helix. The strands are 'laid' together to form the rope, and the way in which they are laid together is called the 'lay.' Now if we begin to tie a knot, we similarly 'lay' together, two ropes, and each rope then forms a portion of a helix. The general rule is this: If the strands of the rope used form right-hand helices (as is the case with the old Alpine Club rope), then in that part of the knot which is subjected to the greatest strain (I use the word 'strain' in its popular sense) the two ropes must each form a left-hand helix. Conversely, if we use a rope, the strands of which form left-hand helices (as is the case with the new Frost rope), then in that part of the knot which is subjected to the greatest strain the two ropes must each form a right-hand helix.



CONSTRUCTION OF THE TRICOUNI NAIL FOR SHOES

"The annexed figures include three classes of knots: simple or elementary knots; knots for uniting two ropes; loop knots. All are shown tied with left-hand rope. The correct way of tying the knots is shown in each case, as well as some incorrect ways. Each knot is shown open, before it is drawn taut.

"The single fisherman's bend, shown in Fig. 7, is excellent for uniting two ropes of similar size for temporary purposes, as it can readily be undone. Hence, it has a tendency to work loose in course of time, and if it is necessary to unite two ropes of similar size for longer periods, it is better to use the figure of 8 tie also known as the Flemish tie, shown in Fig. 4. This, though somewhat complicated, is strong and reliable and has no tendency to work loose.



PILKINGTON ICE AXE (*LEFT*) AND KENNEDY AXE (*RIGHT*)

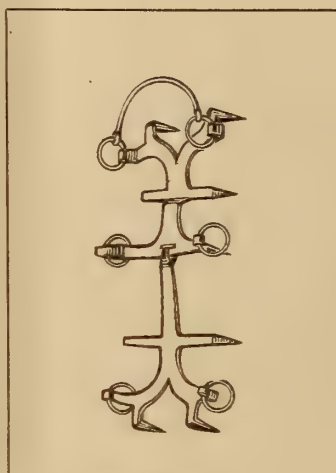
"As regards making a loop in the middle of a rope, no entirely satisfactory knot has yet been devised. The 'middleman noose,' shown in the 1892 Alpine Club Report of the Special Committee on Equipment for Mountaineers, has the fatal disadvantage that under certain conditions, when a pull is applied in a certain direction, it acts as a true noose—that is, as a slip or running knot. The best middle loop at present known is the open-handed loop, which is free from this disadvantage.

"For an end loop, the bowline, shown in Fig. 11, is excellent. The loose end should be secured by half-hitch, or by an overhand knot; the latter, shown in Fig. 12, is preferable."

New rope should be wetted or stretched before use, and the kinks should be carefully worked out by hand. Wet rope should be dried in the shade. The best length of rope for a party of three is 100 or 120 feet.

Crampons add security and are very useful in saving step-cutting on great ice climbs. We illustrate a typical crampon. Crampons are not for use on rocks, except possibly when iced, but they are particularly necessary on steep grass mountains.

Both spectacles and grease are very necessary on glacier expeditions. The spectacles are either of smoked glasses or colored glasses, particularly of green-yellow. Special grease should be used for the face and blackening the face and all round the eyes with burnt cork is also an efficient remedy against sun burn, and suffices in case of loss or breakage of glasses. Captain Farrar recommends a monocular glass rather than field glasses, which are too cumbersome. A light aneroid reading to about 5,000 meters and a compass should form a part of the equipment of all mountaineers, particularly the compass. He is not in favor of cooking apparatus, as he considers cooking on an expedition takes too long and is a needless luxury. Food already prepared should be taken. Tents, sleeping bags, etc., can be secured of the proper variety from all alpine outfitters. A few simple remedies should be carried in rucksacks.



TEN POINTED CRAMPONS

USE OF SAFETY KNOT IN DESCENDING

OTHER CHAPTERS

The third chapter of Mr. Young's book entitled "Guided and Guideless Mountaineering," is a thoroughly scientific discussion of this important subject.

The chapters on rock climbing, climbing in combination, ice and snow craft, reconnoitering, mountaineering on ski, mountain photography, special chapters relating to mountaineering in tropical countries, mountaineering in the Arctic, the Caucasus, Corsica, Himalaya, the Mountains of Norway, Southern Alps of New Zealand, Pyrenees and the Rocky Mountains are all very interesting.

A chapter relating to Himalaya is written by Mr. T. G. Longstaff. It is of particular value in view of the coming ascent of Mount Everest. This book is one of the best works on mountaineering which has appeared for many years.

For our frontispiece and the photographs reproduced on pages 551 and 552 we are indebted to the Federal Swiss Railways.

Research Work of the United States Bureau of Standards

Notes Specially Prepared for the SCIENTIFIC AMERICAN MONTHLY

REFRIGERATION CONSTANTS

For a number of years the Bureau has been conducting researches on the determination of the thermal properties of materials, so far principally the media used in the production of artificial refrigeration.

This work has involved, first, the procuring of the fixed equipment required; second, the selection and training of a staff of investigators capable of carrying out the refined physical measurements necessary; third, the development of methods of measurement suitable for the considerable range of temperatures and pressures involved and the construction, testing, and installation of the special apparatus required; fourth, making the measurements and preparing the results for publication in scientific papers, and making the results available for use by tabulating them in the forms required in engineering practice.

The work so far completed deals with the specific heats of brines, the specific and latent heats of ice, and the specific heat, latent heat, and vapor pressure of ammonia, and with heat transmission through insulating materials and structures. The work completed on ammonia serves as the basis of a complete table of thermodynamic properties of the liquid and saturated vapor, for use in refrigerating engineering. Work on the properties of superheated ammonia vapor is under way and should within the year yield data to complete the tables of properties of ammonia. These tables will be the equal, if not the superior, in point of accuracy, of existing data on the properties of steam. The methods and apparatus developed during the work on ammonia are available and should be used to measure the properties of other media now being used in refrigeration.

When we consider that existing tables are based largely on the work of Regnault done 50 or 60 years ago, it is obvious that systematic measurements of this kind should be made with modern facilities.

It should be pointed out that the work which has been completed thus far is of enduring scientific and engineering value. The best available modern instruments of precision measurement have been utilized, the accuracy that has been attained is high, anl the results have been checked in every instance by independent methods of experimentation and often by entirely different experimental equipment and by different observers.

Of the several steps involved in such a program and enumerated above, the first three are largely completed. The present program contemplates extending the work to the determination of the properties of materials other than ammonia, thus utilizing efficiently specialized experience and equipment which has been accumulated. Materials on which work is contemplated include carbon-dioxide, ethyl and methyl chlorides, and perhaps sulphur dioxide.

WHITE COAT CAST IRON ENAMEL

Enamels of this sort are largely used by stove manufacturers and the chipping off of the enamel has been a serious problem in this class of work. The Bureau is conducting an investigation of the subject and during the past month nine ground coats have been prepared and applied to a number of cast iron samples. It was found that smelting some of the compositions by the frit-crucible method gave unsatisfactory results because of the chipping of the ground coat when applied to the iron. Duplicate mixes were, therefore, prepared by fritting in the kiln at lower temperatures and the preliminary results would indicate that this method is preferable. The comparative tests are being continued and it is believed that considerable information will be gained regarding the effect of various methods of smelting which will form an important part of the investigation. Ground coats which previously have given trouble from blistering with more or less refractory cover coats are working satisfactorily with cover coats of a more fusible nature. It appears, therefore, that it will be necessary to develop a number of typical fusible ground coats to be used in connection with the softer cover coats which are desired by certain of the stove manufacturers.

LOOKING INTO THE CYLINDER OF A GASOLINE ENGINE IN OPERATION

The first tool used by the investigator is usually the eye. He sees a thing happen and the first step in his investigation is likely to be the obtaining of a telescope, microscope or something to enable him to see more clearly.

In the development of the internal combustion engine, however, visual observation of the combustion has played a minor rôle. To be sure, early investigators did provide apparatus that permitted them to look in the cylinder while the engine was operating, but little has been done in this direction with engines operating at the high speeds of the present day automobile types. Interest has centered in what an engine could do rather than how it did it. As a result, measurements of brake horsepower and fuel consumption have been deemed of first importance.

At the present time, the cry for fuel conservation has reawakened interest in the nature of the combustion in the cylinder. Glass induction systems have disclosed how satisfactorily, more often how unsatisfactorily, the fuel has been prepared for combustion. Analyses of the exhaust gases have shown how completely, more often how incompletely, the charge has been burned. If studying preparation for and results of combustion is of value, an actual study of conditions during combustion should surely be worth while.

This has been accomplished in connection with the study of combustion in the one-cylinder Liberty engine at the Bureau of Standards in the following manner: A spark plug shell has been adapted to receive a circular section of glass intended to serve as a window in the cylinder. This assembly can be used in place of either spark plug in the ordinary aviation cylinder, but in this instance an additional boss has been welded to the cylinder in order that conditions might be observed with both plugs firing. Its use was satisfactory in that changes in flame color due to changes in air-fuel ratio were easily discovered. Since the entire combustion stroke is completed in one-sixteenth of a second at an engine speed of 1,800 r.p.m., it is possible to see only the predominant color of the cycle by this means.

To make it possible to observe the combustion in its various stages, another device, a stroboscopic disk, was added. Its purpose is to permit the combustion to be observed during only a small portion of the stroke. Since there is one power stroke for every two revolutions of the crankshaft, this disk is driven at one-half crankshaft speed. The flame is observed through a slot in the disk, the length of the slot governing the length of the portion of the stroke studied. Provision is made for altering the angular relation of this slot to the crankshaft so that any interval of the cycle and, hence, any stage of combustion can be studied.

Observations made possible by this apparatus are not likely to replace any of the more usual measurements. They may, however, prove, and in fact have proved of considerable value

in research work of the nature described by permitting observations of the duration of luminous flames during the power stroke, the characteristic differences in color and brightness at different phases of combustion and their variation with changes in ignition timing, mixture ratio, compression pressure, etc. One observes, for instance, excessively bright flashes of flame of extremely short duration accompanying the phenomenon known as fuel knock or detonation. The cause for this phenomenon is, of course, not revealed by usual observation.

DEVELOPING STANDARD SPECIFICATIONS FOR PAPER BAGS USED IN CONNECTION WITH CEMENT AND LIME

TECHNOLOGIC Paper No. 187 of the Bureau of Standards has lately been published on this subject and is for sale by the Superintendent of Documents at 5 cents a copy.

The object of the paper is to aid the manufacturers of paper bags in meeting the requirements of the cement and lime industries, particularly in the matter of obtaining a suitable paper for the shipment of these products. It contains information relating to the methods of testing and the apparatus employed in determining the quality of these bags. Samples are obtained from the manufacturers and are suitably identified. They are then subjected to two classes of tests known as ordinary and special tests. The first class consists of the usual tests for paper, while in the second class, tests are employed which are specially appropriate for paper bags.

These include laboratory tests for recording the stresses and strains which the paper undergoes in service, tests to determine the breaking strength when the bag is filled with sand, and tests to determine the strength of the adhesive used in the bags.

The results of all these tests are tabulated and from the data thus secured the best quality of bags is chosen. As a result of this work, specifications have been written covering all the qualifications of satisfactory bags for this service.

MEETING OF EXECUTIVE COMMITTEE OF THE AMERICAN ENGINEERING STANDARDS COMMITTEE

A MEETING of the Executive Committee of the American Engineering Standards Committee, the headquarters of which are at 29 W. 39th Street, New York City, was held at the Bureau of Standards at 10 o'clock on Friday, April 8.

The object of the meeting was to discuss the possibility of securing government support for the valuable work which this committee has in hand. Representatives of the War, Navy, Agriculture, Interior and Commerce Departments were present as well as representatives from the various engineering societies holding memberships in the committee.

COMMITTEE MEETING ON REVISION OF TIRE SPECIFICATIONS

ON April 8 a meeting was held at the Bureau of Standards for the purpose of discussing government tire specifications. The Motor Transport Corps, as a very large user of automobile tires, is particularly interested in this problem, and it assisted by sending announcements of the meeting to various tire manufacturers. Representatives of the different companies were particularly requested to be present and in addition the Government was represented as follows: War, Navy, Treasury, Agriculture, Interior, Commerce, and Post Office Departments, the Panama Canal, Shipping Board, Compensation Commission, and the Commissioners of the District of Columbia.

At the meeting ways and means for revising government tire specifications, with the view to adopting better standards, were discussed. Specifications for tires which the Bureau had prepared were submitted to the committee for discussion and the various members suggested such changes as seemed desirable. The committee decided to send a copy of the specifications, together with these recommended changes, to the Rubber Association of America for their consideration and possible further revision. The specifications and the resulting changes are then to be returned to the Bureau of Standards when a second meeting will be called for further consideration of the problem. When completed, these specifications for tires will be available to the various branches of the Government, to municipalities, and to private corporations who buy tires in quantity.

MEETING OF THE ADVISORY COMMITTEE ON NON-FERROUS ALLOYS

THE semi-annual meeting of the Advisory Committee on Non-ferrous Alloys was held at the Bureau on April 20 and was well attended by members of the non-ferrous industries, representatives of the several interested technical societies, and also by representatives from the technical services of the War and Navy Departments. Among the subjects discussed were specifications for hard drawn brass wire for use in connection with the release mechanism of airplane bombs, rotating bands for projectiles, various aircraft problems related to albuminum alloys, bearing metals, the rôle of gases in metals, and the corrosion and etching of metals.

The Committee considered the corrosion problem of the greatest economic importance and thought it desirable to form a joint committee, the organization of which would resemble that of the Joint Committee on the Effect of Sulphur and Phosphorus in Steel, and the Secretary, Mr. Corse, was requested to raise the question at the forthcoming meeting of the Division of Research Extension of the National Research Council.

DISCOLORATION OF INDIANA LIMESTONE

IN order to eliminate the brown stains which frequently appear on new limestone masonry and which are thought to be due to the mortar, tests have been started to determine the effect of using colorless waterproofing materials on the limestone at points where it comes in contact with the mortar. The indications are that if water can be prevented from leeching through the mortar and entering the limestone that stains will not occur. The tests indicate that the greater part of the stain can be prevented by this means.

Another method of eliminating the stains, which is being tried, consists of coating the exposed face of the limestone walls as they are built with a porous coat that can be readily removed. The stains come through the coat and form on the outer surface and by removing the coat the stain is removed also. The insoluble nature of the material which forms the stain makes it very difficult to remove from the limestone, but by allowing it to form on the coating, as mentioned above, it can be readily removed. Since most of these stains form during the erection of the masonry, the method may prove of some value.

NON-FERROUS ETCHING REAGENTS

AN interesting development in connection with the etching of nickel and its alloys is the use of concentrated hydrochloric acid. This appears to be the best reagent for producing contrast without pitting of the surface that has yet been tried. It is rather hard to etch nickel and ordinarily the metal pits considerably and a plain etched pattern, that is, one in which there is no contrast between different grains, is the usual result. Etching in concentrated hydrochloric acid for a considerable period, say one hour or more, gives very satisfactory results.

STRENGTH TESTS OF IDEAL WALLS

AN investigation has been started to determine the compressive strength of Ideal brick walls in coöperation with the Common Brick Manufacturers Association of America. The Ideal walls are laid with common brick but in such a manner as to include an air space in the wall and still be well tied together. There is a considerable saving in the number of bricks, the amount of mortar and the time required to lay these walls over the ordinary solid walls. It is also claimed

that one can plaster directly on these walls thus avoiding the expense of studding, lath, etc. The present schedule calls for the erection of three Ideal walls and two solid ones for comparison. Four of the walls have already been built and will be tested as soon as they are 30 days old. Considerable preliminary work, such as gage calibration and the testing of individual bricks, has already been done.

INVESTIGATION INTO THE CORROSION OF SHEET DURALUMIN

AN inspection has been made of corroded duralumin in the form of thin sheets used in the construction of all metal airplanes. The material became brittle in service owing to the development of intercrystalline "cracks" evidently as a result of corrosion.

The attempt was made to produce the brittle condition in portions of the sheet which apparently were still ductile. By corrosion alone as well as by the simultaneous action of corrosion and stress, it was possible to develop intercrystalline brittleness in the specimens.

Annealing of the material, annealing followed by slight cold rolling and severe cold rolling of the commercial stock did not appear to affect the corrosion materially. In this case it appears certain that the deterioration was the result of the corrosion of the sheet. Brittleness developed because of corrosion from both acid and neutral solutions but an alkaline attack did not appear to cause the development of brittleness.

Notes on Science in America

Abstracts of Current Literature

Prepared by Edward G. Spaulding, Ph.D., L.L.D., Professor of Philosophy, Princeton University

MINIMUM SOUND ENERGY FOR AUDITION

EXPERIMENTS have been made by several different observers to determine the minimum sound energy required for audition, and the variation of the sensitivity of the ear with frequency. The results obtained vary over a considerable range, the values given by Wien (Archiv. für die gesammte Physiologie, V. 97, 1903) showing a much greater sensitivity of the ear and a much greater variation of this sensitivity with frequency than those obtained by Rayleigh (*Phil. Mag.*, V. 38, 1894), Zwaardemaker and Quix (Archiv. für Anat. und Physiol., Supplement, 1902) and others.

A new demonstration of the ear sensitivity seemed desirable and this was undertaken with a thermo-phone as the source of sound, this being a thin metal strip heated by an electric current. The theory of the thermo-phone has been worked out by Arnold and Crandall (*Phys. Rec.*, V. 10, 1917), and a quantitative expression given for the sound energy produced in terms of the electrical input and the constants of the metal strip. In the present experiment, the thermo-phone element was placed in a small telephone receiver case and held tightly to the ear. The other ear was closed by a dummy head receiver and the experiment was conducted in a padded room, so that external noises were eliminated entirely. A second person opened and closed the electric circuit with a knife switch, and the input was reduced in small steps until the observer became uncertain in his judgments as to when the switch was opened and closed, these judgments being indicated by a movement of a finger. The alternating input was measured with a thermocouple and a micro-ammeter. A direct current of one ampere was used in the thermo-phone, which was of platinum, 0.000216 cm. thick. Six frequencies were used, covering the range from 128 to 4096 p.p.s. in intervals of an octave, a vacuum tube oscillator furnishing the alternating currents from which the harmonics were eliminated by means of electrical filters.

The results showed a wide difference in sensitivity for different ears, observations being made on eight ears. Some of the ears showed as great a variation of sensitivity with frequency as is indicated by Wien's data, the energy necessary for audition at 128 p.p.s. being 100,000 times that required at 2048 p.p.s. The smallest rate of energy flow necessary in any observation was about 10,000 times the minimum found by Wien, and was 2.2×10^{-8} ergs per square centimeter per second, the frequency being 2048 p.p.s. The corresponding particle displacement is 0.025 $\mu\mu$.—Abstract from article by F. W. Kranz, *Physical Review*, March, 1921.

VULCANISM AND MOUNTAIN-MAKING

IN an interesting article in *The Journal of Geology* for February-March, 1921, Dr. R. T. Chamberlin discusses Vulcanism and Mountain-Making. Many folded mountain ranges of both thin-shelled and thick-shelled types, says the author, are characterized by cores of crystalline rock, in considerable part of igneous origin. In many of these the crystalline rock clearly belongs to an old terrane arched up in the folding process and exposed by erosion; but in many other cases the intrusive relations of the igneous rock have led to the belief that it was intruded into the axis of the folded range in a late stage of the arching process. The wide prevalence of this phenomenon has been emphasized by Daly.

Comparing the two types Dr. Chamberlin says that in those thin-shelled ranges in which overthrust faulting has been a dominant feature, intrusions formed in this way should not be conspicuous in the marginal portions where the phenomena of overthrusting are best displayed and the shell was thinnest, but rather in the heart of the deformed belt, where the shell involved in the diatrophism went somewhat deeper and lifting was relatively more important. As an example of this, the author cites the following:

In the Scottish Highlands on the western border the planes of overthrusting dip eastward under the deformed belt; in Scandinavia they dip westward likewise beneath the strongly deformed belt. Together, Scottish thrusts on the west and Scandinavian thrusts on the east, they constitute seemingly a wedge similar to the Appalachian wedge of Pennsylvania.

The outer marginal portions of ranges of this type, both folded and faulted, he says, are particularly superficial. In the great overthrusts but very shallow flakes have been moved. The very low inclination of the fault planes does not carry them to great depths. Beneath the planes of overthrusting, the underlying strata, if of incompetent material, are found to be contorted in many places, but this folding rapidly dies out away from the thrust planes. Such shallow deformation does not greatly facilitate the movement of magmas. But back in the heart of the deformed belt the disturbance goes much deeper, and uplifting with relief of pressure beneath is more pronounced.

The thick-shelled mountains, on the other hand, Dr. Chamberlin says, have been characterized by open, gentle folding, moderate crustal shortening affecting a deeper zone, by strong uplifting, and the extravasation of much lava. Vertical diastrophism seems to dominate over horizontal. Normal faulting is an important accompaniment, occurring either incidentally as a part of the uplifting process or as a result of subsequent relaxational movements of the raised plateau-like area. Iddings has given an excellent exposition of the part block faulting has played in the extravasation of lava. According to his belief, block faulting under tensile stress offers the principal outlets for the escape of lava. To quote: "The deepest fractures starting from the zone of potential magma should

permit its eruption and intrusion between blocks that tend to part from one another by reason of the tensile stress." The wide prevalence of normal faulting in mountains of the thick-shelled type should therefore be an important factor in the rise of magmas. The steep inclination of normal fault planes carries these fractures to greater depths than the more gently inclined thrust faults. At the same time normal fault planes because of the governing tensile stress, at least locally, become the more ready avenues of escape for the lavas. While rhyolite and other acidic lavas have appeared in vast quantities in some places, andesitic and basaltic lavas appear to have been, on the whole, more abundant. This may perhaps be in part because the greater liquidity of the basic lavas makes migration along narrow fissures easier for them than for the more viscous silicic magmas.

In conclusion, Dr. Chamberlin says that the formation of thick-shelled mountains is characterized in general by much volcanic activity. There may also be important intrusives bearing a close relation to the mountain-making stresses. The growth of thin-shelled mountains, in contrast, is accompanied by very little volcanic activity, at least within the truly mountainous belt. Little igneous activity of any sort is manifested in the marginal and most strongly overthrust portions of thin-shelled ranges; but in the heart of the deformed belts, where there has been more uplifting and the affected zone goes deeper, granitic and other intrusions are a common and probably characteristic feature. It is, of course, also to be recognized that a region which, in an earlier age, has undergone deformation of the thin-shelled type may, in a later age, after long continued denudation, participate in orogenic movements of the thick-shelled type and so become the scene of volcanic activity on a large scale.

THE MEASUREMENT OF SEA WATER SALINITY

In the *Journal* of the Washington Academy of Sciences for April 4th, 1921, Mr. A. L. Thuras discusses the practical application of the electrical conductivity method of measuring sea water salinity.

Heretofore the only reliable method of measuring the total salt content of sea water has been by chemically titrating for the amount of chlorine present. The relation of chlorine to the total salts being a constant, a measure of the salinity is thereby obtained. Salinity is defined as the number of grams of total salts in 1,000 grams of sea water. The titration method, being a laboratory method, requires that the samples after collection be stored in suitable bottles until they can be tested on shore. The disadvantages of such a method are: The loss or breakage of samples, possible errors from evaporation and handling, and the great undesirability of not knowing the physical properties of the waters while they are being investigated.

During the Ice Patrol of 1920 an opportunity was given to use the electrical method of measuring sea water salinity on board ship. An apparatus consisting of instruments and parts secured from the Bureau of Standards was set up on shipboard and several hundred determinations of salinity were made. The operation of the apparatus was simple and convenient and at no time did weather conditions interfere with the measurements. This apparatus consisted of: A wheatstone bridge, a Leeds and Northrup alternating current galvanometer, a specially constructed electrolytic cell designed for a salinity recorder, a hand regulated temperature bath, and a rebuilt 1/12 horse-power direct current moter to give 120 volts, 60 cycles of alternating current when connected to 110 volts direct current.

All measurements were made 25° C. and a table was prepared to give salinities directly from the balanced bridge readings. The complete apparatus was tested each day by standard sea water taken from a supply which had been carefully measured both by a chemical method and a density method before beginning the cruises. This supply of sea water lasted throughout the cruises. The temperature of the electrolytic cell bath could easily be held to within 0.03° C., and the bridge, after balancing the moving coil of the galvanometer so that the center of mass was fairly near the axis of support, could be set to a value corresponding to 0.02 in salinity. No electrical capacity or inductance was necessary for balancing the bridge, and variations in the voltage and frequency of the generator had no appreciable effect on the bridge setting. With the apparatus used the determinations were accurate to 0.05 in salinity, or better than 0.02 of one per cent.

HEIGHT, HYGIENE AND PHYSICAL TRAINING

Dr. Clelia Duel Mosher, of Stanford University, finds through the study of 4,023 women who have entered the university during the past thirty years statistical evidence that American women are increasing in size. Through a careful study of the measurements of these women at the time that they entered the university, Dr. Mosher draws the conclusion that the height of the average woman has increased between an inch and an inch and one-tenth during this period.

Dr. Mosher, also from the same statistics, concludes that there has been a noticeable increase in the average weight of American women.

This physical improvement in the average American girl Dr. Mosher ascribes mainly to two factors: The change in fashion, causing women to wear clothing which interferes less with hygiene, and the increased physical activity among women, which has been brought about by this change in dress and by the development of physical training and sports in schools and colleges and the change in the conventional attitude toward these activities for women.

Since these measurements were all taken of girls at the time they entered college, the increases are indicative of a general improvement among women and are not due to the benefits received from physical education in the university. Furthermore, the improvement noted is not confined to California women or even to western women, but apparently is applicable to all American women. The students whose measurements have been studied and compared over thirty years came from all parts of the country, and Dr. Mosher has compared the measurements of California girls with those of girls from other parts of the country for fourteen of the thirty years and finds that the curves showing increase in height and weight over this period are upward for both classes.

Another element which still further emphasizes the improvement shown is the fact that the age at which girls enter Stanford has decreased during the thirty years so that the women who have shown gains in height and weight during the latter portion of this period are, in addition, younger than those who were measured during the earlier years. This decrease in age is likewise true of both Californians and non-Californians.—Abstract from *School and Society* for March 26th, 1921.

A NEW PHYSICAL TEST FOR A MAN

In *School and Society* for January 29th, 1921, Dr. D. A. Sargent of Harvard University gives an account of a new "physical test for a man."

In popular estimation, says Dr. Sargent, it takes so many inches and so many pounds and a certain size of chest girth to make a man, and this estimation is borne out largely by experience.

Such measurements alone do not tell us, however, anything of the texture and quality of the parts covered, *i.e.*, how much is fat or bone, and how much muscle, nor do the measurements alone give us any information of the innervation of the parts upon which power and efficiency so frequently depend. Even if we accept the physical measurements of a man as an indication of his potential power, as so many of us almost intuitively do, we are soon taught by experience that there is in many men an unknown equation which makes for power and efficiency which has never been determined and which can only be measured by an actual test.

The important question is, what is this unknown equation and how can it be simply and practically tested and numer-

ically expressed? With a good many others Dr. Sargent has been wrestling with this problem for years by the way of strength tests, endurance tests, speed tests, etc., but without coming across any one method that was perfectly satisfactory.

Dr. Sargent then describes what he has found to be the simplest and most effective of all tests of physical ability. The individual to be tested stands under a cardboard disk, or paper box cover, heavy and stiff enough to hold its form, about twelve inches in diameter, held or suspended from ten to twenty or more inches above his head. He is then requested to bend forward, flexing the trunk, knees and ankles, and then by powerful jump upward, straightening the legs and spine, to try to touch the cardboard disk with the top of the head. Swing the bent arms forward and upward at the same time the legs, back and neck are extended, will be found to add to the height of the jump. When the disk has been placed at the highest point above the head that can be just touched in jumping, this height is measured. The difference between this height and that of the total stature is of course the height actually jumped.

Now, if this height is multiplied into the total weight of the body at the time of making the jump, it will give one some idea of the amount of work done in *foot pounds* as usually calculated. But it will be observed, no credit is given for lifting the full weight of the body from the deep knee or squatting position to the perpendicular position, which difference represents about half the height. The total work depends upon how heavy and how tall the individual is. Thus, if a man weigh 150 lbs. and is 70 inches tall, one half of that height would be 35 in., which, multiplied into the full weight and divided by 12 inches would equal 437 foot-pounds, thus:

$$\text{Formula A} = \frac{\text{Weight} \times \text{Half the Height}}{12} = 437 \text{ F.P.}$$

In estimating work done outside of the body, this amount of energy expended is not always taken into consideration as power expended. In the new test, however, an individual must not only do a certain amount of work in physical effort in rising from the crouching attitude to the perpendicular position but he must generate force enough to project his body 10, 20 or 30 inches in the air, above the height attained in the standing position. If this person weighing 150 pounds should jump 20 in. above his height, this weight multiplied by 20 and divided by 12 would equal 250 F.P. thus:

$$\text{Formula B} = \frac{\text{Weight} \times \text{Height Jumped}}{12} = 250 \text{ F.P.}$$

This amount of work done would be acceptable according to the usual methods of estimating man power. Both the A and B formulæ are frequently used for tests of the physical basis of efficiency. The height jumped will depend a good deal upon the length of the legs and trunk that make up the total stature, the tall man being favored—therefore an exact ratio of the height jumped to the stature would seem to make the test more equitable. Thus, if the man weighing 150 lbs. was 70 in. tall and jumped 20 in. above his head, the ratio of 20 to 70 would account for this advantage in height. This ratio may be obtained by the following formula:

$$\text{Formula C} = \frac{\text{Height Jumped} \times 100}{\text{Total Height}} = .285$$

Although the formulae A, B and C are interesting in enabling one to account for his efficiency or deficiency in the test, these formulæ may be dispensed with in favor of one including the three important factors under consideration. If then in the new test we multiply the total weight by the height jumped and divide this product by the total height of the person in inches the result will give a fair index of the effort made in the smallest number of figures.

Thus if the individual tested weighed 150 lbs. and jumped 20 in. above his head and was 70 in. tall, the formula for his efficiency index would be as follows:

$$\text{Index} = \frac{\text{Weight} \times \text{Jump}}{\text{Height or Stature}} = \frac{150 \times 20}{70} = 42.8$$

Dr. Sargent gives tabular results of trying out his test, and concludes that the test as a whole may be considered as a momentary try-out of strength, speed, energy and dexterity combined, and one that furnishes a fair physical test of a man, solving in a simple way the unknown equation as determined potentially by height and weight.

AN AMMONIA GAS PROBLEM AND ITS SOLUTION

Research does not always involve tedious experimentation. When helpful knowledge of former research is available, and men coöperate, problems are sometimes quickly solved. The solution of a problem for one purpose may be useful in many others, if properly recorded. The technical and scientific societies and journals and our libraries can be helpful, if utilized; also the Research Information Service of the National Research Council.

Ammonia in some forms is, with impunity, used daily for many household purposes, but ammonia gas in quantity is deadly. Nevertheless, this gas is extensively employed for refrigerating and other processes. It may be safely used, if rightly controlled. Some years ago many fatal accidents occurred due to safety valves on ammonia pipes discharging the gas into the operating rooms of refrigerating plants, hotels and manufacturing establishments. As a consequence, Massachusetts and New York passed laws requiring safety valves to have a discharge pipe through the roof to extend ten feet above the roof, if the adjoining building were higher.

In New York one of the first problems encountered under the new law was the piping in the many-storied Woolworth Building on lower Broadway. There were but few data available by which the size of the ammonia discharge pipe could be figured, because little was known about the difference of pressure required to put a given quantity of super-heated ammonia gas through a long pipe, the pipe being open to the air at one end. Experiments were then made to deduce a formula for the flow of ammonia gas in a pipe open to the air. What quantity would flow through a pipe of given length and diameter, under a given pressure at the entrance end of the pipe? Similar experiments were made on the discharge of steam. From these data it became evident that a 2-inch safety valve had to have a 6-inch pipe to discharge, even with 5 pounds pressure above the atmosphere at the entrance of the pipe, the quantity of ammonia gas that would pass through the 2-inch safety valve.

The old idea then came into the minds of two engineers working on the problem, that the flow of steam from 275 pounds absolute pressure into the air was practically the same in quantity as the flow of steam at 275 pounds absolute pressure into a chamber where the pressure was 150 pounds absolute. This led to the design of an ammonia safety valve discharging against back pressure. The question was: What was the upper limit of back pressure that an ammonia valve could discharge against?

Other series of tests were made to determine this minimum pressure. It was found that the flow into a reservoir where the back pressure was 0.585 times the entrance pressure (that is, somewhat more than half the entrance pressure) was exactly the same as the flow into a reservoir where the pressure was atmospheric. As a result, a safety valve was designed which would discharge against back pressure. Tests on this valve showed that the theory was correct. Ammonia safety valves as built today are made in such a way that they are capable of discharging against this high back pressure.

This, of course, means that the discharge pipe in cases like that mentioned, instead of being six inches in diameter, can be of a very much smaller size, since the entrance pressure in this pipe is now approximately 150 pounds instead of five pounds above the atmosphere. The resulting economy and convenience are obvious, as well as the satisfactory solution of this detail problem in the safe use of ammonia gas.—Information furnished by Prof. Edward F. Miller, Massachusetts Institute of Technology, Cambridge, and here published by courtesy of the Engineering Foundation.

Science and National Progress

Edited by a Committee of the National Research Council

Dr. Vernon Kellogg, Chairman, Dr. R. M. Yerkes, H. E. Howe

The National Research Council is a cooperative organization of the scientific men of America. It is established under the auspices of the National Academy of Sciences and its membership is largely composed of appointed representatives of the major scientific and technical societies of the country. Its purposes are the promotion of scientific research and of the application and dissemination of scientific knowledge for the benefit of the national strength and wellbeing.

RECENT WORK OF THE RUSSIAN ACADEMY OF SCIENCE*

By Sergius Oldenburg,
Permanent Secretary

The following article giving an interesting account of the persistence of activity on the part of the Russian Academy of Science in the face of great obstacles, appeared recently in the Russian daily newspaper "Novy Poot" (The New Path), published in Riga.—Editor.

Very recently I have had an example of the surprising degree of isolation which segregates the peoples of Europe from each other in these days in spite of their geographical proximity. Word has come to me from Sweden that scientists there believe that "the famous Russian Academy of Sciences is destroyed" and that our "museums and libraries are in ruins." My colleagues Grabar and Vinogradov have already presented the status of Russian museums and libraries. I would like to speak about the work of the Academy of Sciences. During the nearly 200 years of its existence the Academy has lived up to the idea of its great founder, Peter the Great, to foster creative thought and to stimulate the application of scientific achievements to practical life; this was true in the 18th and 19th centuries and it is still more clearly evinced in the 20th century. Lately the Academy has been in a position to cluster about itself some 600 scientific men working in its laboratories, museums, libraries and on numerous commissions. One of the greatest difficulties which confront the scientist in Russia is the almost absolute impossibility of publishing scientific work. However, through great effort the Academy jointly with its principal Commission for the Investigation of the Natural Resources of Russia succeeded in publishing in 1920 nearly 500 signatures[1] *i.e.*, about 8,000 printed pages.

The publication of scientific work really constitutes the foremost problem of today, since the Academy of Sciences alone has in manuscript form nearly 4,000 signatures (64,000 printed pages) which are ready for the printer, but cannot be published. This matter was properly presented by the Academy to the Council of People's Commissars by whom it was given special attention. Among the papers published may be mentioned a series of contributions to a voluminous work on the "Natural Resources of Russia," in which very complete data on this subject are being brought together—an especially important work just at this time when we must have an inventory of the natural resources which constitute our economic basis. Detailed monographs on separate topics, such as those on sizing clays, fire-resisting materials, building materials, tea, tobacco, medicinal herbs, etc., are being issued along with this large set.

Among the other publications we may name the *Russian Journal of History*, and the work of Academician Shakhmatov, deceased in 1920, on "The Ancient Destinies of the Russian Race." Over 1,000 pages of the Academy's "Proceedings" were published containing a series of articles on various subjects, mainly on mathematical and natural sciences.

If only our print shops would commence to work at more normal speed, we would have plenty of material for scientific papers, accumulated and accumulating.

We should now note a very important tendency in contemporaneous Russian scientific work. I speak only of the Russian work known to me, but I believe that an analogous situation exists also in the West. We are now inclined to sum up definitely the work of the past, to make clear the existing working hypotheses and the confines of our scientific achievements. This is quite necessary for economization and organization in scientific work. A certain crisis in science, a necessity for finding new paths, has indeed been felt for a number of years; we have been collecting an enormous amount of material not being quite certain whether we do it properly and whether we gather the most necessary data and withal we have felt the inadequacy of our methods of work and the defects of our organization.

The war suddenly diminished the opportunities for collecting new data and thus naturally forced us to turn to theoretical studies and also created the need of summations.

As an illustration of such summations we have mentioned the conspectus of the Academy's Commission on Natural Resources of Russia. We may also point to a joint undertaking of the same commission in collaboration with another academic Commission for the Study of the Racial Composition of the Population of Russia. Funds for this work are given by the Supreme Council of National Economy.

A regional description of Russia is in preparation under the editorship of Academician Fresman. Russia is being divided into regions mainly on the basis of geographical and economic principles. There is to be a comprehensive account, beginning with the geographical description of the country, followed by data regarding its inorganic and organic wealth and ending with the people and their productive activity. Nearly 100 signatures are ready for print and conferences are being held relative to the commencement of the publication of the entire series with colored charts and plates. The same Commission has published the first issue of a series entitled "The Wealth of Russia."

The Commission for the study of the racial make-up of Russia has issued a racial map of Bessarabia prepared by Professor Berg, and two numbers of "Essays on Classification of the Population of Caucasus" by Academician Marr, and "The Talishes" by Marr and B. V. Miller. Besides, there are ready for print issues on the Tarangs (emigrants from eastern Turkestan) in Semirechye, on the mountaineer Tadjiks in Pamir and several issues on the racial composition of the population of a series of provinces in the Volga region and in Central and Northern Russia, also a series of papers on separate tribes of Siberia. The last edition of the racial map of White Russia with an explanatory text by Academician Karski is now entirely exhausted; this map had three editions and there is now in preparation a revision in greater detail.

The two above-mentioned academic commissions, especially the Commission for the Investigation of the Natural Resources of Russia, have engaged a large number of workers. More-

*Translated from the Russian by Michael Shapovalov, of Washington, D. C.

[1]Signature is a printer's term, designating 16 pages.

over, they are collaborating with the Russian Geographic Society which is preparing a large geographical dictionary of Russia, and with the Geographic Institute in compiling a detailed and comprehensive description of the Petersburg province, also with the Academy of the History of Material Culture which is conducting a series of ethnological investigations and inquiries. In addition, the commission on natural resources works in the domain of geology in close union with the Geological Committee and in the domain of hydrology with the Hydrological Institute, an offshoot from the Commission like many other institutes; optical, ceramic and others.

Among the voluminous collateral undertakings carried on by the Academy should be mentioned the "Fauna of Russia" issued with the intimate assistance of the Zoological museum of which 20 volumes have already been published. It is to be regretted that the typographic derangement prevents further publication of this important synthetic work. The same fate has overcome another manuscript of the Academy, "Flora of Siberia," of which only one number has appeared in the current year, although as with the "Fauna of Russia" abundant material is ready for the printer. The Zoological and Botanical Museums are working diligently on these undertakings.

Following the heavy losses suffered by the Academy in the death of Academicians Lappo-Danilevski, Dyakonov and Shakhmatov, the permanent historic commission, upon electing Academician S. F. Platonov as its chairman, again resumed its work and expects to issue the first volume of a "Collection of Edicts of the Collegium of Economy" which has long been awaited by the Russian historians and which is of so great economic importance. Along with this the commission expects to resume certain other of its investigations, particularly since it is now known that the scientific correspondent of the historico-philosophical section at Rome, though in very straitened material circumstances, continued his work without interruption. It is to be hoped that the communication with him may improve. Besides, the permanent historic commission has been instructed to look into the possibilities of uniting at the Academy all archaeographical work in general, since it is especially desirable to organize now because of the existence of the Glavarchiv consolidating all Russian archives.

The museums of the Academy being deprived of the opportunity to send expeditions because of present world conditions are engaged in the task of revising collections, a work of prime importance for every museum, but one which can scarcely be done adequately under normal conditions. Some museums, however, such as the mineralogical and ethnographical, in spite of the absence of expeditions, have received extensive entries from private collections. The ethnographical museum in its annual report complains that hundreds of boxes of valuable collections made during a number of years by the collaborators of the museum, Marvardts in India and Shirokogorov in Manchuria, remain unmoved awaiting transportation.

The library of the Academy and the Academy's House of Pushkin, which has accumulated a vast library of new literature, have been enriched by very remarkable collections. The very rich Vorontsov collection of manuscripts, the library of Longinov, and a whole series of archives of writers and their separate manuscripts have been placed in the Academy. It is much to be desired that the new library building already occupied too long by various temporary hospitals may soon be returned to the Academy, as otherwise it will remain impossible to make use of hundreds of thousands of new entries.

It is obvious that a many-sided and broad activity cannot be exhaustively reviewed in a single brief newspaper article. I may state here that the annual report on the work of the Academy and its institutions, concerned merely with the enumeration of facts, comprises a volume of over 400 pages. I wished only to emphasize certain phases of the Academy's work and thus to show that the Russian Academy of Sciences of which Russia may justly be proud and which soon will complete two centuries of its existence, is not only not destroyed, but is working diligently. It is true that the conditions of labor are hard; we have no new western books which are so urgently needed; we feel a great want of material for scientific work, often it is very cold in winter in working quarters, the supplies of electricity and gas are insufficient, frequently the scientist lives in cold and hunger. All this is so and we do not deny it, but nevertheless the work is in progress, work genuine and fruitful, of course far less intensive than it might be under better conditions of living, but nevertheless, I repeat, it is genuine work. Those who remain to work in Russia believe in Russian science, in the Russian people, and in their duty to Russia and to its great culture, the duty to work as long as strength lasts, to work not in fear, but in fidelity.

Breaks in our cultural work must not be and we firmly believe that, in spite of whatever hardships may befall the Russian scientists by virtue of all that is now going on throughout the whole world, there shall be no break and we, the passing old generation, shall turn over the work to the worthy rising generation of Russian scientists together with our last will and testament—work so long as ye live!

PAPER MAKING MATERIALS

Dr. C. J. West has compiled a reading list of paper making materials which has been reprinted from the *Paper Trade Journal* and which can be recommended to all those concerned with the subject. The evaluation of paper making material is given in the following quotation from William Raitt of India:

"1. It must have no value for any other economic purpose, either to the spinner, rope maker, or to any exclusive extent at least, to the feeder of cattle.

"2. It must be a free gift of nature, of spontaneous self-sown growth, capable of natural reproduction, and not liable to exhaustion under a reasonable system of cropping.

"3. It must mature annually, or at periods not exceeding three years, so that a pulp factory can obtain supplies from the area surrounding it in perpetuum.

"4. No fiber requiring cultivation is admissible. This does not of course apply to fibrous material obtained as a by-product, *e.g.*, straw as a waste from grain cultivation.

"5. No material requiring manual or mechanical manipulation for the separation of the fiber from the body of the plant is admissible, the cost of such separation being prohibitive, and such fibers being invariably of greater value to the spinner.

"6. Its habit must be gregarious and in sufficient local abundance to bring cost of cutting and collection within economic limits, a plant which grows in tufts or patches at long distances apart not being admissible.

"7. It must contain at least 30 per cent of cellulose. This is an item which may vary in accordance with the local cost of other factors, but I think it is safe to assume that under no conditions will a yield of less than 30 per cent pay.

"8. The total quantity available within economic collecting radius of a mill site must be sufficient to produce at least 2,500 tons of pulp annually. This is also a figure which must vary in accordance with the cost of other factors. Generally it will be much higher. I place it at that, because there are locations where the other conditions are so favorable that even this quantity will pay, and because it is doubtful whether any local advantages could bring a smaller quantity to a profitable basis.

"9. No material is admissible which does not grow in a locality possessing cheap labor, and water for manufacturing uses.

"10. And it must grow within economic range of power, lime, and transport to seaport."

Reading lists of this type represent a tremendous amount of tedious work and it is hoped that full use will be made of results obtained.

Progress in the Field of Applied Chemistry

Notes Culled from Current Technical Literature

By H. E. Howe, Member of American Chemical Society

AT THE SILK EXPOSITION

"One of the most interesting features of the Japanese Exhibit at the recent Silk Exposition, New York, was an actual representation of the amount of silk required for the production of a silk dress and jacket of average size. These garments require in their manufacture one and one-quarter pounds of raw silk, which is obtained by the reeling of 1,800 cocoons. As a matter of fact, 2,000 cocoons are required, but there is always a certain loss which reduces the number of unpierced or sound cocoons for reeling the best chops. These 1,800 cocoons weigh four pounds. The 2,000 silk worms that produce these cocoons require for their food 125 pounds of mulberry leaves. It is said that when the silk worms, in large numbers, are feeding on the leaves, the sound one hears closely resembles that of falling raindrops.

"Incidentally, the relatively small amount of silk required in a silk dress, as shown above, may throw some light on the amount of dye required to color it. As a rule, medium shades on silk do not require more than two or three per cent of the dye. There being 20 ounces of silk in a medium weight dress, the amount of dye used for coloring it is considerably less than one ounce, which at the average prices for silk dyes makes the dye cost not more than twenty-five cents."

CHEMICAL MONOGRAPHS

By arrangement with the Interallied Conference of Pure and Applied Chemistry which met at London and Brussels in July, 1919, the American Chemical Society was to undertake the production and publication of scientific and technologic monographs on technical subjects.

"Two rather distinct purposes are to be served by these monographs. The first purpose, whose fulfilment will probably render to chemists in general the most important service, is to present the knowledge available upon the chosen topic in a readable form, intelligible to those whose activities may be in a wholly different line. Many chemists fail to realize how closely their investigations may be connected with other work which on the surface appears far afield from their own. These monographs will enable such men to form closer contact with the work of chemists in other lines of research. The second purpose is to promote research in the branch of science covered by the monograph, by furnishing a well digested survey of the progress already made in that field and by pointing out directions in which investigation needs to be extended. To facilitate the attainment of this purpose, it is intended to include extended references to the literature, which will enable anyone interested to follow up the subject in more detail. If the literature is so voluminous that a complete bibliography is impracticable, a critical selection will be made of those papers which are most important."

Thus far the following monographs have been secured and are now in progress of being written or printed:

The Animal as a Converter.
Chemical Effects of Alpha Particles and Electrons.
The Chemistry of Enzyme Actions.
The Properties of Electrically Conducting Systems.
Carotinoids and Related Pigments: The Chromolipins.
Thyroxin.
The properties of Silica and the Silicates.
Organic Mercury Compounds.
Coal Carbonization.
The Corrosion of Alloys.
Industrial Hydrogen.
The Vitamines.

A NEW ACHIEVEMENT IN AMERICAN DYES

In in its March issue *The Color Trade Journal* makes some observations upon recent achievements in American dye manufacture from which the following extracts are quoted:

"A new dyestuff of remarkable value to the industry has been recently added to the list of achievements of the American dye chemist. This product is Indophen Blue now made on a large scale. . . . It is a sulfur dye of remarkable clearness and brightness of tone, far surpassing in this respect even the German pre-war dyes of the same general type, such as Immedial Indone. It is also remarkable for its high tinctorial strength, which is far greater than any sulfur blues hitherto or at present on the market. But its color value would be of little avail were it not for the fact that the dyeings on cotton obtained with Indophen Blue have a fastness to light, washing and rubbing that is superior even to indigo, while the fastness to alkali, acid, fulling and boiling is equal in every respect to indigo.

"Indophen Blue is considerably brighter than vat dyed indigo blue and more violet in tone; it approximates more closely in fact to the brighter and redder brom-indigo. On account of its great fastness it is of especial interest, and this feature brings it into the same category as indigo. The simplicity of its method of dyeing, however, will make it more broadly available to the dyeing trade than indigo, as the latter requires a specially prepared hydrosulfite vat and a technique which limits its use to a special coterie of indigo dyers.

"Blue is the great staple color of the dyer in all parts of the world, and more blue color is dyed (with the exception of black) than all the other colors put together. Indigo has always been the great staple dye to be used for the dyeing of blue on account of its beauty and fastness. It requires, however, a complicated process of dyeing and cannot be applied like the usual run of ordinary dyes; consequently it is not available to the average dyer. Previous to the war the great German dye factories sought to produce a sulfur color which would take the place of indigo and still possess similar properties of fastness. A number of sulfur blues came on the market, but most of these were dull in appearance, were weak in tinctorial strength, and were expensive as compared with indigo. It is true there were very bright and beautiful blues among the basic dyes and the direct cotton colors, but none of these had the required fastness especially to light and washing, and consequently could not take the place of indigo, though they could be applied to the fiber with great simplicity.

"The advent of Indophen Blue shows that American chemists are equal in ingenuity and resourcefulness to their German competitors, for they have even gone ahead of the latter in producing a sulfur blue, the search for which had long been prosecuted. The German factories were never quite successful in getting out a blue of this type which possessed all the required properties. . . ."

The employment by one of the large dye manufacturers of certain foreign chemists who applied for work has given rise to a considerable discussion. It is worthy of note, therefore, that the employment of these specialists is not in any way a criticism of American achievement or expression of doubt with respect to the ability of American research workers. It is simply a way in which valuable time can be saved, making it possible to combine special and technical skill with the results of American research laboratories. This combination has already resulted in a production of sulfur black, the equal of which the world has not heretofore seen. This dyestuff may be regarded as the first of a series which must result from so favorable a combination as has been secured.

NEW PROCESS FOR MAKING STEEL

FOR the following note relative to a new process developed by a French company for the purpose of manufacturing steel directly from the ore, *Mechanical Engineering* is responsible. A rotary furnace similar to the type employed for making cement is said to be used in the new process:

"In this process the ore is charged at the upper end and works its way toward the lower end as the furnace slowly revolves—at the rate of one revolution in three minutes. Pulverized coal is used for fuel. The air which supports the combustion is previously heated to about 1,000 deg. cent. in a regenerator similar to that connected with an open hearth furnace.

"The temperature of the gases as they leave the furnace is said to be 300 deg. cent. and by the nature of the process these gases contain 44 per cent carbon monoxide. This gas, of course, may be used for heating purposes. The slag is tapped off the top of the metal which is poured into the ingot molds.

"It is stated that three qualities of metal have been produced, including pig iron of a grade between gray and white, hard steel and malleable iron. These results are obtained by varying the ore charge and the temperature of the process."

SIXTY-FIRST MEETING OF THE AMERICAN CHEMICAL SOCIETY

THE sixty-first meeting took place in Rochester, New York, the week of April 25 and proved to be one of the most successful in the Society's history. Over two hundred and eighty papers were presented for discussion before the eleven sections and divisions, in addition to general meetings before which Senator Wadsworth of New York and Congressman Longworth of Ohio made addresses. There was an important symposium on contact catalysis and an interesting discussion on the fuel of the future with particular reference to the part which cellulose and its conversion by chemical methods into fermentable carbon hydrate will play in the solution of the problem. The symposium on drying was held in the industrial division. One interesting observation was made in this discussion relative to the turbulent motion which must be secured in air currents passing through dryers in order to secure uniform drying. In the absence of a turbulent or mixing motion there is a tendency to have formed a layer of moisture, saturated air, which interferes with the further drying of the material. Thus a series of trays may show satisfactory drying on one edge only. This is believed to be due to the fact that the air upon striking such an edge is thrown into motion and drying continues until a saturated layer or quiet air is produced. Air must travel at a greater linear velocity than water to obtain a satisfactory turbulent motion.

With relation to the potash situation, further details were given as to the possibility of obtaining potash from the green sands of New Jersey. There is now under construction a plant capable of treating one thousand tons of green sands per day which will require about nine hundred tons of quick lime which will be produced in the largest lime kiln installation in the country. From these raw materials sixty-five tons of caustic potash will be produced per day and of course other potash salts can be manufactured. Experiments have had to do with the effect of fine grinding upon the reaction, the time and temperature at which treatment must be carried forward, the ratio between the quantities of green sands, quick lime and water which is best for the purpose, and to what extent the reaction can be accelerated by the addition of various salts. When the plant is in working order it will be possible to compete with any sort of potash salt under present day conditions.

That the alcohol situation so far as the chemical industry is concerned is becoming acute was emphasized upon several occasions. The chemist knows alcohol is a solvent which is as important in organic chemistry as is water in inorganic chemistry. Industrial alcohol may be regarded as of equal value with sulfuric acid, nitric acid and the alkalis which are frequently called the foundation stones of chemical industry. The efforts of well meaning people to regulate the consumption of alcohol is tending to have a restricting influence upon industry which is in no way connected with beverage alcohol. A committee of the Society has been appointed to study the situation in the hope that beverage alcohol and industrial alcohol may be separated in the minds of those interested in prohibition.

INDUSTRIAL FELLOWSHIPS

THE eighth annual report of the industrial fellowships of the Mellon Institute, Pittsburgh, has been issued and contains several interesting bits of information including a list of the industrial fellowships in operation at the Institute on May 1, 1921. The diversity of the work will be indicated by a list of the names of the fellowships. These fellowships are endowed from $2,500 to $16,800 per annum. A list of subjects follows:

Synthetic Resins	Emulsion Flavors
Bread	Inks
Illuminating Glass	Cements
Zirconium	Perfumes
Fish Products	Fiber
Fuel	Yeast
Plastics	Silicate
Soap	Magnesia Insulation
Enameling	Coke
Food Container	Organic Synthesis
Synthetic Acids	Insecticides
Protected Metals	By-Products
Stove	Glue
Sulphur	Distillation
Oil-Shale	Fertilizer
Nickel	Dental Products
Corrosion	Cleaning
Flotation	Metal Ware
Duplicator	Laundry
Glass	Refractories
Oil	Asbestos
Quartz	Fruit Beverages
Gas	Magnesia Products
Tar Products	

SOLVENTS PRODUCED BY BACTERIA

IN the March number of *Chemical Age* appears a discussion under this head by H. E. Hall. We are familiar with discussions relative to harnessing Niagara and other great forces of nature but none of us have listed such diminutive things as bacteria among these forces. Solvents are among the most important of reagents used in chemical processes and among the saturated alcohols important as industrial solvents methanol has been about the only one which has refused to be made by fermentation process. Propyl, butyl and amyl alcohols as bacteriological products are recent additions of commercial importance to the list of industrial solvents.

"Among other new solvents which are making their appearance in the industrial field are diacetone alcohol and isopropyl alcohol. The first, like acetone, is a solvent for both the nitrate and acetate of cellulose. There are at least two approved methods of manufacturing this material and its field of usefulness would seem to depend largely upon production costs. With acetone, the principal raw material, available at unusually low prices, it would seem an opportune time to develop the possibilities of diacetone alcohol.

"We are told that isopropyl alcohol can now be produced economically from petroleum. The alcohol being miscible in all proportions with water appears to resemble in properties ethyl alcohol rather more closely than it does butanol or fusel oil. Isopropyl alcohol is not potable and since it possesses valuable solvent properties, its field of usefulness might well cover some of the fields now using denatured ethyl alcohol. The extent to which it will replace denatured alcohol will probably depend largely on the relative prices of these products."

Progress in the Field of Electricity

Summaries and Excerpts from Current Periodicals

By A. Slobod

MOVING PLATFORMS FOR CROSS-TOWN LINES

Some interesting details in regard to the proposed construction and method of electric drive of moving platforms to handle cross-town traffic in 14th, 42nd, and 57th Streets, New York, was recently published in the *Electric Railway Journal.*

The proposed electric corner system of propulsion will permit the use of platforms mounted on car trucks which will effect a material reduction in the cost of construction, operation and maintenance and also of the space required. The distinguishing characteristic of this system is the method of propulsion. The three-phase induction motor of the squirrel-cage type is used. The parts of this motor corresponding to the stationary or primary element are straightened out into sections about 5 feet long and placed midway between the rails in the roadbed, while those corresponding to the revolving element, also straightened out, form a continuous short-circuited secondary mounted on the bottom of the car. The primary elements, when energized with three-phase current by induction, magnetize the short-circuited secondary which extends continuously along the bottom of the car. The result is that the force created between the induced secondary current and the shifting field of the primary propels the car.

The scheme proposed is to use three platforms of various width moving at different speeds. The high-speed platform carries seats for two persons spaced at 3-ft. intervals. As the speed of the different platforms depends on the frequency of the three-phase current applied to the primary, it is clear that any platform may be operated at a lower speed by changing the frequency supplied to it in case it should be desired to shut down one platform and operate the other two, or in the case one platform only is to be operated. The application of this system to the 42nd Street loop would require three platforms, each approximately 10,100 feet long. The seating capacity of the 9-mile platform would be 31,680 passengers per hour in each direction. The weight per seat for all three elements would be roughly 375 pounds while that of a loaded subway train is approximately 1,800 pounds per passenger.

THE DISTRIBUTION OF ELECTRICITY

Two papers appear in the *Journal of the Institution of Electrical Engineers* for January, 1921, dealing with this subject. One was presented by Mr. W. B. Woodhouse; it contains a discussion of the problems involved in organizing a system of distribution as a compound organism from a number of isolated nuclei. The principal conditions of economic distribution are determined by conflicting technical and financial considerations. The author reviews in detail the area of supply involved, the factor of time in relation to capital expenditure, sources of supply, distribution of load, pressures of supply, load factors and losses, networks, high-pressure cables and overhead lines. The following conclusions are reached from a consideration of all the conflicting conditions: (1) Three or more pressure systems are necessary for economy. (2) The detail distribution pressure is fixed by considerations of use; in England a single-phase pressure of from 200 to 250 volts is established. (3) The size of the distributing substations is determined by the density of load and the size of the power users' installations. (4) The distance between these substations depends primarily on the detail distribution pressure; the substations should be as widely spaced as considerations of pressure-drop permit. (5) The main distribution pressure is determined by the number of substations in the area, the total load, and the economical balance between expenditure on mains and on substations. In industrial areas of England a pressure of 10,000 volts has been found economical. (6) The extent of each power distribution network may be reduced with economy as the load develops and the size of substations increases. (7) The transmission pressure is primarily determined by a consideration of pressure-drop and total power, no advantage is gained by exceeding a minimum fixed to meet demands anticipated to arise in a period determined by the rate of growth of load. (8) Main substations are determined in number by the load on the power distribution networks and the pressure of distribution, as well as by the number of generating stations.

The other paper was read by Reginald O. Kapp and dealt with economic aspects of extra high-tension distribution by underground cable. The author points out that, with heavy cost of feeders on modern power schemes, due to the centralization of the generation of electricity in very large power stations, a saving in the capital outlay on the extra high tension distribution system will assume an economic importance comparable with that of reductions in coal consumption. Various means for keeping the cost of the distribution as low as possible without sacrificing safety are discussed.

It is also shown that the position of the power station with reference to its load influences the cost of feeders very greatly indeed and methods of determining its most economical position are given. It is shown that the same methods can be employed to determine the most economical position of the step-down transformer houses.

Rules are given with reference to the design of cable layouts and for determining the most economical voltage of transmission. After an allowance for diversity factor and stand-by cables has been made, the total kva. capacity of feeders leaving a power station is still considerably greater than the maximum station load, on account of uneven sharing of the load; means are suggested for reducing this discrepancy. The author also shows that, on account of the capacity of cables to store heat, their safe continuous rating may be lower than their peak load. The true safe continuous rating is the equivalent continuous load of a daily load curve, and a simple method of finding this is described. The author further discusses the cost of unit electricity as depending to a notable extent on the consumer's load and power factor and, therefore, tariffs devised to encourage an improvement of both are equally to the advantage of supply undertakings and consumers.

The papers are followed by a very extensive discussion.

THE DELETERIOUS EFFECT OF FIBERS ON THE ELECTRIC INSULATING POWER OF OILS

The deleterious effect of water on transformer oil has long been known. Recently attention has been drawn also to the importance of the more complete elimination of other impurities. Of interest in this connection is a series of experiments by Thomas McLaughlin described in *Electrician* (London), for March 18, 1921, pp. 325-327. The author comes to the following conclusions: In dealing with insulating oils great care is necessary to obviate dust particles and fibers, which if present would be liable under the action of an electric field to form up in chains and seriously decrease the insulating power of the oil. Fibers might easily be introduced by using cotton rags in cleaning apparatus. These fibers even though of a very fine and practically invisible nature will have a high conductivity and may easily form a chain for a breakdown by a rush of current and the passage of a spark. The presence of free water particles is also undesirable, for if dust particles

or fibers are present they will join them and render them more conducting, while they may, if very favorably placed, themselves link up and form a chain. If this chain is formed under high voltage it will act as a medium for a spark, the passage of which will release carbon particles which in turn can form a conducting chain.

These results may thus be taken as verifying from a different viewpoint those obtained by previous researches; in particular they seem to point to the truth of the statement that "it may then be positively stated that only a single fiber of poor insulating value will be sufficient to break down the insulation of a transformer, however high the quality of the oil may be as a whole, for the puncture will occur at the weakest point. In so far as a fiber may reduce the specific resistance of an oil hundreds or even thousands of times, it can well be regarded as forming a weak point.

In the course of the research much information as to the electrical properties of liquid paraffin was noted. It seems to be much superior to any other oil as an insulator viewed from the point of view of specific resistance. At about 1,000 volts per cm. its specific resistance was of the order 10^{14} or 10^{15} ohms. Between the parallel plates used a spark in the oil could be obtained at about 2,200 volts per mm.

The *Electrical World* of April 23, 1921, states in an editorial that the experiments mentioned above thus raise the questions whether complete precaution is taken against the passage of fibers into the oil and whether oils should not be examined more rigidly for impurities of this character and whether conductivity tests such as those described in the paper have not some advantages over the usual breakdown tests.

HYDRO-ELECTRIC PROGRESS IN CANADA DURING THE RECENT PAST

J. B. Challis, Director of Water Power, Department of the Interior, Ottawa, contributes a detailed account of Canada's water power development. The total development work completed or under construction in 1920 represented approximately 650,000 hp. of installed capacity. The total developed hydroelectric power in the Dominion now stands at 2,460,000 hp. Taking the population at 9,000,000, the development per 1,000 of population is 274 hp., a figure far ahead of the United States and ahead of any other country in the world except Norway.

The province of Ontario still leads in magnitude of the new developments. In pursuance of the coöperative agreement made in 1919 between the Hydroelectric Power Commission of Ontario and the Department of the Interior, the Dominion Water Power Branch is now responsible for all basic investigation respecting water resources, while the province undertakes the detailed investigation for and construction of actual developments. The total of development under construction in this province amounts to 500,000 hp. The provinces of Nova Scotia and New Brunswick entered on an active policy of provincial government development of their water-power resources. Great activity was shown in organized general hydrometric investigation to meet future requirements and in the investigation and planning of further considerable developments.—*Electrical World*, Vol. 77, pp. 931-934, April 23, 1921. Also *Electrical News*, Vol. 30, pp. 33-36, April 1, 1921.

ELECTRICAL RESISTANCE OF METALS

The *Physical Review* for February, 1921, publishes a brief summary of an extensive series of measurements which are to be published in detail in the Proceedings of the National Academy, measurements made to determine the effect of pressures up to 12,000 kg. per sq. cm. and of temperatures from 0° to 275° C. on the resistance of lithium, sodium, potassium, gallium, bismuth, mercury, calcium, strontium, magnesium, calcium, titanium, zirconium, arsenic, tungsten, lanthanum, neodymium, carbon-amorphous and graphitic, silicon and black phosphorus. The data for tungsten and magnesium are improvements on data previously published; the data for the other substances are new. The first six of these elements were studied in both the liquid and the solid states. The pressure coefficients of solid calcium, solid strontium, and both solid and liquid lithium are positive, the coefficient of bismuth is positive in the solid state, but negative in the liquid.

A previous theoretical discussion of measurements of the effect of pressure on resistance suggested most strongly that in metallic conduction the electrons pass through the substance of the atoms, and that the mechanism by which resistance is produced is intimately connected with the amplitude of atomic vibration. This view is here given quantitative form. The classical expression for conductivity $= (e^2/2m)\ (nl/v)$ is retained; the number of free electrons is supposed to remain constant, their velocity is taken to be that of a gas particle of the same mass and temperature, and their mean free path is supposed to be many times the distance between atomic centers. The variations of path are then computed in terms of the variations of amplitude, and thus the variations of resistance are obtained and checked with experimental results. It is shown that the theory in this form explains Ohm's law, gives the correct temperature coefficient and the most important part of the pressure coefficient, avoids the difficulty of the classical theory with reference to specific heats, indicates a vanishing resistance at low temperatures, leaving open the possibility of super-conductivity, and retains the classical expression for the Wiedemann-Franz ratio. Besides these quantitative checks the theory is shown to be entirely consistent qualitatively with all the new data; in fact, many of these new results, particularly the effect of pressure and temperature on the relative resistance of solid and liquid, seem to demand this conception of metallic conduction.—P. W. Bridgman, *Physical Review*, Vol. 17, pp. 161-194, February, 1921.

THE LIMITATIONS OF THE STOP WATCH AS A PRECISION INSTRUMENT

In many scientific and engineering measurements the quantity, time, is an important factor. A high degree of precision can of course be obtained with our present-day astronomical clocks in proper environment and their usefulness extended by electrically relayed circuits. This method, however, is cumbersome, leaves much to be desired and is not generally applicable to laboratory measurements, not to mention the wide variety of field work. The result is the more convenient stop watch, frequently resorted to by engineers.

Mr. A. L. Ellis contributes an illustrated and detailed discussion of the stop watch, its characteristics and errors, costs of various grades, etc., and comes to the following conclusions: Due to inherent errors of timing train and those due to mechanical limitations and design, practically nothing is gained in accuracy by increasing the number of jewels beyond the standard seven-jewel movement. An attempt has been made to reduce the inherent error in at least one instance by increasing the rate of vibration of the balance, but the price at which it was offered was out of all reason considering the accuracy gained and the cost of manufacture. Some of the larger errors do not follow the law of probability, for while the errors may be either plus or minus, and vary somewhat in magnitude, some at least depend upon the interval of time being measured, as for instance, in the case of the Jockey Club type of stop watch; in this case if the interval being measured is less than thirty seconds, the hand will jump forward upon being started again; if the interval is more than thirty-five seconds the hand will jump backward on starting again.

The sources of error in a watch are such that at least two watches should be used simultaneously for timing an event, timing intervals of varying length if possible, the mean of all observations to be taken. The stop watch as applied to engineering measurements is not sufficiently robust for the purpose, and it is to be hoped that manufacturers will make a special effort to produce a stop watch suitable for this class of service.—*Journal of the American Institute of Electrical Engineers*, Vol. 40, pp. 104-112, February, 1921.

Survey of Progress in Mechanical Engineering

Prepared Under the Auspices of the American Society of Mechanical Engineers

AIRCRAFT STATISTICS

The following preliminary statement of the general results of the 1920 census of manufactures with reference to aircraft has been issued by the Bureau of Census, Department of Commerce, furnishing a detailed statement of the quantities and values of the different types of aircraft manufactured during the year 1919, prepared under the direction of Mr. Eugene F. Hartley, Chief Statistician for Manufactures.

Reports were received from 31 establishments engaged in the industry during 1919 showing products for the year values at $14,372,643, as compared with 16 establishments in 1914 with products valued at $789,872. Of the 31 establishments reporting for the year 1919, ten were located in New York; four in Ohio; two each in California, Massachusetts, and Missouri; and one each in Connecticut, Indiana, Illinois, Louisiana, Maryland, Nebraska, New Jersey, Pennsylvania, Rhode Island, Washington and West Virginia.

The following is a summary of statistics of the industry for 1919, the "All other products" reports consisting chiefly of airplant parts, engines, and repair work:

Number of establishments	31
Total value of products	$14,372,643
Airplanes:	
Number	432
Value	$3,466,452
Seaplanes:	
Number	230
Value	$4,580,016
Value of work done during year on airplanes and seaplanes not completed	1,658,670
All other products, including parts and repair work	4,667,505

COATS STEAM CAR

Description of the new steam car being built at Indianapolis and involving several apparently novel details.

In particular, the engine is located in the rear axle and in fact, the engine axle and differential function all in one, the engine itself in its housing being just about the size of the ordinary rear axle gear case.

The housing of each half of the axle carries three thick cylinders set at 120 deg. apart. These cylinders are exactly like those of the internal-combustion automobile engine with poppet valves, pistons and connecting rods. The bore is $2\frac{3}{4}$ inches, the stroke is 3 inches. The three connecting rods in each half of the axle are pivoted to a crank pin integral with the drive shaft of each wheel. At a speed of 40 miles per hour the engine is running at about 500 revs. per minute.

The exhaust steam is taken by return pipe to the condenser located in front of the boiler in the position of the ordinary radiator.

The whole engine has therefore six cylinders and the general arrangement is shown in Fig. 1. The car for five passengers completely equipped weighs less than 1,800 pounds and has less than 40 moving parts. It has no carburetor or ignition accessories, no clutch, gear shift, flywheel, propeller shaft, universal joints or differential; uses kerosene as fuel and is claimed to be very economical on that.

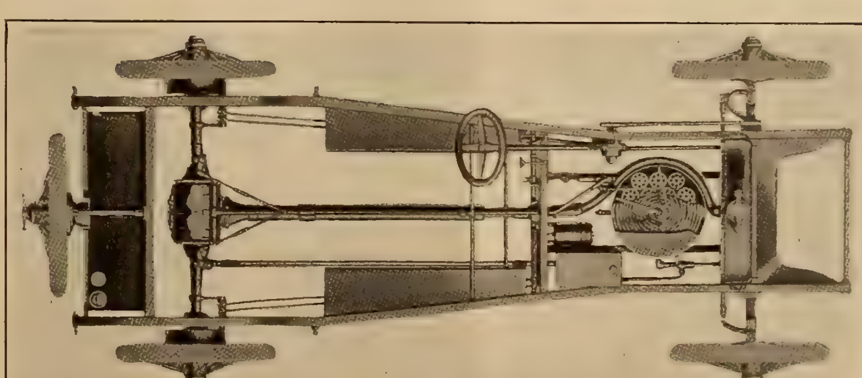


FIG. 1. PLAN VIEW OF THE CHASSIS OF THE COATS CAR

It is stated that the design was worked out primarily by a Norwegian engineer, but developed to its present state of refinement in America.—*The Accessory and Garage Journal*, Vol. 10, No. 11, March, 1921, pp. 88-89.

COLUMBIAN FLASK STEAM CONDENSER

Description of a condenser which is said to be extensively used in ice manufacturing plants. The steam enters at the bottom of the head of the condenser into the first or reboiling compartment formed by baffle plates. It travels then the entire length of the condenser ascending into the next compartment, back through the full length of the condenser, again ascending into the next compartment until it reaches the top compartment at the end of which is provided a small opening for the escape of foul or gassy steam, the two in the center being the main condensing compartments.

The distillate travels back over the baffle plates descending to the bottom of the condenser in the same manner in which the steam traveled as it ascended over the baffle plates. This distillate reboils on its way back to the bottom of the condenser and is finally carried off through the distilled water outlet in the bottom of the condenser down into the ice cans below, where it is finally frozen into ice cakes.

The steam entering at the bottom of the condenser is generally from 218 to 220 deg. fahr. with a pressure from ½ to 1 pound. The cooling water which is evenly distributed over the outside of the condenser is usually from 90 to 100 deg. fahr. The hot steam passing back and forth up through the condenser meets the distilled water and reboils it so thoroughly that by the time the distillate reaches the bottom of the condenser in the reboiling chamber, there is no further need of a separate reboiling, yet the temperature in this lower compartment is at about 212 deg. fahr.

Columbian flash condensers are made mostly by hand. The rivets are finished from the inside in order to leave a smooth surface on the outside as a protection against the quick collection of alkalies and minerals that are found in the water. They are usually equipped with a 4-inch steam inlet and 2-inch distilled water outlet, and an additional small outlet in the end of the condenser near the top for the escape of foul steam. —*Refrigeration*, Vol. 28, No. 2, March, 1921, p. 39.

PALM OIL AS ENGINE FUEL

At a recent meeting of the Association for the Improvement of Colonial Materials, Major Trentals of the Belgian Colonial Army described developments in the use of palm oil and other vegetable oils grown in the Belgian Congo in internal combustion engines.

The tests were carried out on a stationary two-cycle semi-Diesel engine developing 8 to 10 horsepower at 500

r.p.m. The palm oil employed was of medium or low quality containing considerable amounts of free fatty acids and impurities. The only really special feature on the engine was an arrangement made for keeping the palm oil in a sufficiently liquid condition. For this purpose the cylinder cooling oil was used and together with the hot exhaust gases maintained the oil in the feed tank at a temperature high enough to ensure liquidity, and at the same time evaporate any water which might be present. In addition to this a gasoline vapor lamp was placed under the tank.

The feed tank consists of a series of compartments divided from each other by fine mesh metal screens to filter the oil before admitting it to the injection pump.

The engine starts on gasoline and finishes on gasoline in order to remove any residual palm oil from the feed pipes, which might get clogged by the congelation of the oil when the engine is at rest. [The average melting point of oil is about 37 deg. cent. (98 deg. fahr.) which varies with purity and origin.]

A certain amount of water is injected into the cylinder. The palm oil referred to in this paper is obtained from the fleshy pericarp of the palm fruit and not palm kernel oil contained in the palm nut. Palm kernel oil does not differ much in heat value from peanut oil.—Paper before the Association pour le Perfectionnement du Matérial Colonial. — Abstracted through *Gas and Oil Power*, Vol. 16, No. 186, March 3, 1921, pp. 85-86.

THE SPRENGER PROCESS OF MAKING CONCRETE

By E. Weiss

In this process a machine is used which its inventor calls Aero-Malaxeur. The principle of this machine consists in projecting wet sand and gravel through an atmosphere saturated with the binding material which may be blown in in the state of complete pulverization by some kind of a blower.

The machine essentially consists of slightly inclined mixing cylinder rotatable in its bearings. In the top part of the drum there is a hopper for storing the sand and gravel. Into this hopper there is discharged at a predetermined rate water to give the materials the desired degree of moisture. At the

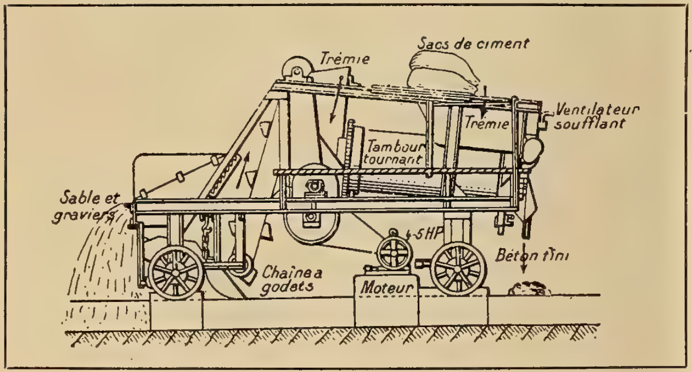


FIG. 2. DIAGRAMMATIC VIEW OF THE SPRENGER AERO-MALAXEUR CONCRETE MIXING MACHINE

(*Sable et graviers*—sand and gravel; *Tremis*—hopper; *Secs de ciment*—cement sacks; *Tambour tournant*—rotating drum; *Ventilateur soufflant*—blower; *Beton fini*—finished concrete; *Moteur*—motor; *Chaine a godets*—bucket elevator.)

other end of the cylinder there is a double proportioning hopper containing the binding elements, such as chalk, cement, or a mixture of the two. The graduated orifices admit these materials into the cylinder in a strictly predetermined proportion and a strong draft of air coming from a blower carries them to meet the materials coming from the other end of the drum.

As each grain of sand or gravel is projected from the upper hopper into the cylinder where it moves in an atmosphere filled with the binder, it is therefore entirely and intimately comixed with it.

The machine is of the continuous operation type and is entirely automatic, the concrete arriving at the bottom of the cylinder being discharged into cars or bins. It is claimed that with this machine the lack of uniformity of sand or gravel is less important than in the production of concrete by other means.—*La Nature*, No. 2444, February 5, 1921, pp. 95-96.

WATER COOLING TOWERS

By I. V. Robinson

Water cooling towers are extensively used in Great Britain in connection with the largest central stations where the plant has outgrown the natural supply of circulating water and has to supplement it by artificial means.

Water cooling apparatus differs considerably in type, but the principle and method of cooling is the same in all types and

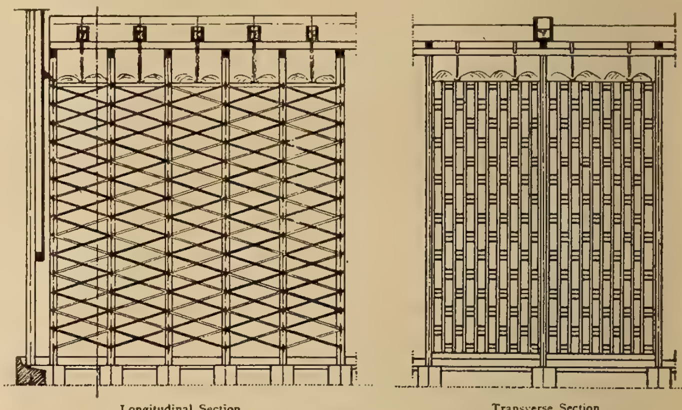


FIG. 3. DIAGRAMMATIC ARRANGEMENT OF COOLING STACK OF FILM COOLING TYPE

i.e., bringing into intimate contact with the hot water, a large quantity of air at a lower temperature.

The coolers are classified as follows:

1 Chimney type
   a natural draft
   b forced draft
2 Open type
3 Spray type

In a cooling tower heat is absorbed from the water by the air through two distinct actions: ((a) Direct heating of the air, and (b) evaporation of a portion of the water.

Under the usual working conditions in Great Britain the heat absorbed by evaporation is about 75 per cent of the total heat absorbed as shown by a brief calculation in the original article.

Of the various types of natural draft chimneys cooling towers are most generally used. The water is admitted at a height varying from 16 feet to 25 feet above the sea level and is distributed over the whole area of the tower by main distribution troughs. From these troughs it falls into smaller troughs pitched closer than the larger distribution troughs and is allowed to fall by various special methods differing with various makers on to the cooling staff. Air is admitted usually around the whole perimeter of the tower at the base of the stack, openings about 5 feet to 6 feet high being left for this purpose. The various designs differ mainly in the methods used for initially distributing the water over the cooling stack and bringing the water and air into intimate contact.

Cast iron or porcelain pipes may allow the water to fall into porcelain disks. If the water is under pressure and the height of fall and shape of disk proper, the whole thing may be broken into a fine spray.

Another method is to use dipper bars let into the side of the main distribution troughs. These bars have a concave surface along which the water flows, overflowing then on to the cooling stack. The object in all cases is to divide the water so that it presents a large surface to the air and yet at the same time to allow the air to ascend the tower freely.

It is because of this second condition that the splash system has not found much favor with designers lately.

Fig. 3 shows a section through a cooling stack which de-

pends upon film and not splash. After rebounding from the splasher disks under the small troughs, the water falls upon a number of inclined laths and flows down them. At the lower end of each lath there is a V in it through which the water passes and then falls upon the upper end of the next inclined lath and so repeats the process till the bottom is reached. In the stack illustrated the water flows over fourteen inclined laths, seven sloping in one direction and seven in the reverse direction. Each vertical set of laths is comparatively narrow and the sets are so arranged that adjacent laths at any level are inclined in the opposite direction. This alternate arrangement allows a free passage for the air up the stack, the air having to move horizontally only the width of one lath when passing each lath.

Towers are usually built over a tank varying in depth up to 6 feet, and the concrete forming the tank has an important bearing upon the stability of the tower. Many local authorities in England stipulate that a structure such as natural draft cooling tower shall be able to withstand a wind pressure of 30 pounds per square foot and do not consider that this condition is met unless the resultant of the horizontal wind pressure and the weight of the tower and the concrete tank to which it is securely attached passes through the middle third of the base.

The original article shows how these magnitudes are computed.

The author presents some facts, however, which would indicate that this regulation is excessively stringent, and believes that there would probably be an ample margin of safety if the resultant of the wind pressure and weight of tower and tank passed through the middle half of the base with the tank empty, as the effect of the water which is usually in the tank would be to bring the resultant into the middle third. (As regards the testing of cooling towers, it is necessary first to determine clearly the object of the test.) Manufacturers usually guarantee that when the tower is dealing with a stated quantity of water per hour at a given temperature it will reduce the temperature by a definite amount under specified atmospheric conditions; and if the object of the test is merely to ascertain whether or not this guaranty of performance has been maintained, the test is quite simple and very few tests on cooling towers pretend to do more than this. But if it is desired to test the tower completely so as to learn whether any improvement can be made, a much more detailed test becomes necessary, a matter which is briefly discussed in the original article.—*Beama* (a monthly journal devoted to the interests of British electrical and allied engineering), Vol. 8, No. 3, March, 1921, pp. 227-234.

Progress in Mining and Metallurgy

Abstracts of Papers and Recent Articles

Prepared Under the Auspices of the American Institute of Mining and Metallurgical Engineers

FIREDAMP IN THE GOLD MINES OF THE FAR EAST RAND

BY T. N. DEWAR

DURING the past few years trouble has been experienced in certain mines of the Far East Rand through occurrences of firedamp. As firedamp is generally associated with collieries, it created some surprise when it appeared in the gold mines. The collieries in the Far East Rand area are singularly free from firedamp and the death roll from explosions can be almost entirely credited to the gold mines.

In the Brakpan mines, the first accident happened March 19, 1913. A fissure was encountered at the face from which a large quantity of water issued, and the winze became partly flooded. A pump was installed to handle the water. In due course the water level fell suddenly, so a pumpman went down to ascertain the cause and found that the water had fallen about four inches from the hanging in the hollow. When he held his lamp up to make the inspection an explosion occurred and he sustained fatal injuries. Later on it was ascertained by tests that the gas was firedamp. Nobody suspected the occurrence at the time. It is obvious that the gas had accumulated behind the water in the hollow and was released by the lowering of the water level by the pump. The depth from the surface to the face of the winze was about 3,470 feet.

After describing a number of other instances the author arrives at the following conclusions:

It is noticeable from the occurrences described that the firedamp in the mines of the Far East Rand is found principally in the presence of upthrow faults, which bring the foot-wall shales into position for driving through. In the majority of cases, faulting and water seem necessary for the presence of gas. In some cases sulfureted hydrogen accompanies the firedamp, but not always. It is assumed by many people that the gas travels with the water down fault planes from the coal measures. The great problem is to account for the vertical movement of the gas of nearly 4,000 feet.

It would appear that in places there is a definite connection through faulting from the coal measures to the gold measures. The dolomites form a convenient water channel all over the area. They are jointed and large quantities of water lie in the crevices.

The difficulty is just why firedamp should not take the line of least resistance and escape up the faults to the surface, instead of traveling down them. The fact remains that firedamp is generally found in mines where the coal measures are developed above or where a connection with them is available through the dolomites for gas to travel. On the other hand, the gas is usually found actually in or about the foot-wall shales that are very jointed. Carbon is also found occasionally on the contact of the reef and the shale where, especially if associated with pyrites, a great enrichment of values takes place. Perhaps under heat and pressure some reaction may take place between the pyrites, water, and carbon in or under the shales to produce something in the shape of firedamp.

Redmayne, in "Ventilation of Mines," states that "a blower of firedamp has occurred from time to time in the famous Van Lead mine, near Llanidloes, in Montgomeryshire, the vein of which traverses rocks of the lower silurian age. It is difficult to account for the presence of firedamp at this mine as there are no carboniferous rocks in the neighborhood and decaying timber could not account for the existence of a blower of gas. Possibly it owes its origin to the decay of plant or animal life of the silurian period, and has been pent up through the succeeding ages, or it may be due to the chemical action of acidulated waters or mineral substances. It is a peculiar feature of the emissions at this mine that they are accompanied by sulfureted hydrogen."—Abstracted from the *Journal* of The Chemical, Metallurgical and Mining Society of South Africa.

RETORT FOR ASSAYING OIL SHALES FOR OIL YIELD

BY L. C. KARRICK

THIS paper describes the assay retort used by the Bureau of Mines in the research work on oil shales now in progress at the Intermountain experiment station of the bureau at Salt Lake City, Utah, and at the Colorado coöperative oil-shale laboratory, Boulder, Colo. The retort which was de-

veloped through experimentation in the Bureau's laboratories is recommended as a simple device for field and laboratory use where rapid assays are desired with results of duplicate tests agreeing within one per cent. In setting up the apparatus, great care must be exercised to see that it is air-tight. The paper gives specific directions for preparing contact surfaces.

It is important to use a sheet-metal jacket around the retort while heating, leaving about ¼-inch clearance at the sides and enough to clear the clamp screw on top. Notches are cut in the jacket for ring support and delivery tube. A cover of asbestos board is necessary to reflect heat down against the retort lid, otherwise oil will condense on the inner side of the lid and drip down on to the shale in the retort, thus causing losses by secondary distillation.

OPERATION OF THE RETORT

Crush the shale to pass a ¼-inch screen, and weigh out just enough to fill the retort (2) level full, permitting the charge to rest loosely in the retort. After the lid is fastened carefully in place and tested for leakage, place the retort in ring support (3), adjust jacket (11) and cover (12), start the burner (1), then fasten the graduated cylinder (9) and reflux condenser (10) tightly in place. Use a very small flame at first, so that no oil will appear within 45 minutes after starting. Before distillation makes any considerable progress, the interior or coolest shale should be at least as hot as the vaporizing temperature of the oil evolved, otherwise vapors will migrate to the central or coolest part and condense there, causing losses of oil by cracking on redistillation of the condensed oil.

When 2 or 3 cubic centimeters of oil have accumulated, the flame should be increased; it is imperative to distill rapidly after oil vapors begin. If oil first appears in about 45 minutes it will then be safe to double the size of the flame, and thereafter every 20 to 40 minutes increase the heat by an equal amount. The oil should accumulate in the graduate at a uniform rate, and the analyst will soon become adept at pushing the rate of retorting without exceeding the condenser capacity. With the average oil shale, the recovery when the actual oil-producing period is approximately 2 hours will be 5 per cent greater than when distillation lasts 6 hours. When distillation is completed in less than 2 hours, there is danger of inaccuracy from exceeding the condenser capacity, and undoubtedly from decomposition of oil vapors by excessive temperatures. Distillation should be rapid enough, however, to prevent stagnation of oil vapors within the hot retort or connection, and should progress at a uniform rate. If oil droplets appear dangerously near the top of the reflux condenser (10), the rate of heating must be retarded slightly.

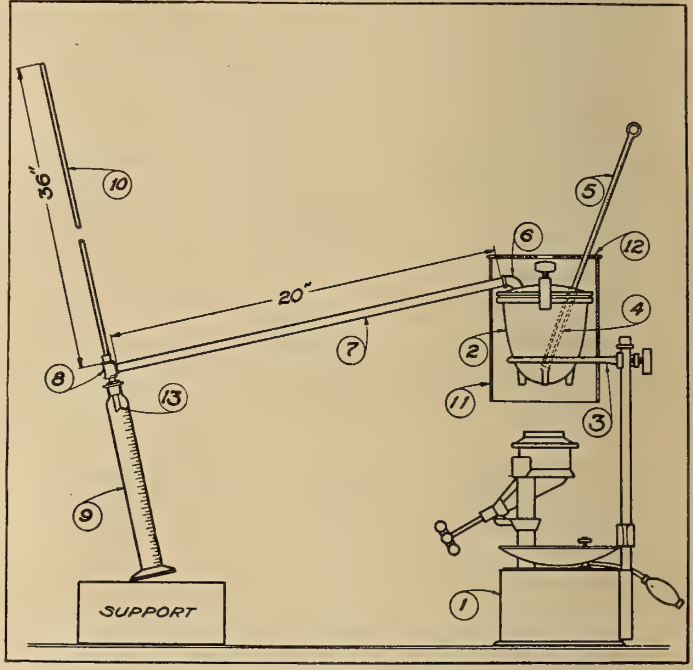
If retorting has progressed correctly, the rate of oil accumulation will decline suddenly as the last oil is distilled off, and, when this cessation becomes apparent, the flame should once more be increased the usual amount. A white gas may appear at the end of the run, but this has been found to be non-inflammable and to carry no oil vapors. The delivery tube should be kept fairly warm throughout the run, to prevent the oil from congealing therein. When the bottom of the retort has become a dull red, it can be safely assumed that the distillation of oil is completed, as this temperature is well above the final oil-yielding temperature for all oil shales.

MEASUREMENT OF THE OIL ACCUMULATED

Lack of experience in measuring the accumulated oil will cause a much greater error in results than lack of refinement in retorting technique, or imperfections in the retort.

The stoppered graduate and contents must be warmed until the oil is in a very fluid condition. Allow the oil to settle well, as some water is given off near the last stages of distillation, and will remain suspended in the partially congealed oil. In order to read accurately the volume of the oil and water, it is necessary to assist the formation of a perfect meniscus by releasing any oil and water clinging to the sides of the graduate. This is best accomplished by revolving the graduate, while still warm, between the palms of the hands. Read the upper level of the oil and then the lower level, if it is well defined and is not rendered obscure by emulsion, sediment, or clinging oil and water. The following procedure will facilitate accurate reading of the lower meniscus and also provide against the possibility that water sediment may not have settled out completely. Draw off with a pipette all except a few cubic centimeters of the oil while still warm, dilute the remaining oil with 10 to 20 cubic centimeters of clean gasoline, and agitate gently till the emulsion disappears. Allow the shale-oil and gasoline solution to settle, then draw off and add gasoline as before. Repeat as often as required, until a clear meniscus results. From the number of cubic centimeters of oil collected, calculate the gallons of oil per ton of shale.

The paper gives methods for more accurate measurement of the oil, together with a table of factors for facilitating calculations. The complete paper (Reports of Investigations, Serial No. 2229) may be obtained from the Bureau of Mines, Washington, D. C.



OIL SHALE ASSAY RETORT

1—Dangler Lamp; 2—C. I. Mercury Retort (1 pint); 3—Ring Stand; 4—Thermometer Well; 5—400° C. Thermometer; 6—Std. W. I. Street Ell; 7—¼" Std. W. I. Pipe; 8—Std. W. I. Tee; 9—100 cc. Graduate; 10—5/16" I. D. Pyrex Tubing; 11—Sheet Iron Shield; 12—Asbestos Cover; 13—¼" Pipe Nipple, cut at 45° angle.

INVESTIGATION OF FATIGUE OF METALS UNDER STRESS

BY H. F. MOORE

AT present the writer is connected with an investigation of the so-called fatigue of metals under stress. So far we have studied the more fundamental and simple case of the repeated stress, without the additional complexity of impact, which might bring in other factors. We feel that this investigation which has been in active progress for a little over a year, has shown more conclusively than has been shown before that steel under repeated applications of stress, reversed from positive to negative, will not fail below some fairly clearly defined limiting stress, which so far as we can see, does not bear any definite relation to the ordinary elastic limit, being as large as the elastic limit in some cases and about one-half the elastic limit in others.

I do not know of any evidence in favor of the theory that metals materially change their crystalline structure under re-

peated stress. The crystals are broken under repeated stress. The second theory, advanced by Bauschinger, the German scientist, is that under repeated stress some inherent property of the material changes its elastic limit, it is an inherent property of the material, possibly some property of the amorphous cement between the crystals. The third view is that all fatigue of metals is the result of the spread of damage from little localized overstresses.

I do not feel justified in stating my positive belief in the third view as against the second, but I have yet to run across a case of failure of steel or other metal, either in the laboratory or in service that could not be explained by the gradual spread of damage from some nucleus.

In the steel work of any building there are undoubtedly many thousands of places where structural damage was done—where riveted members were bent into place cold and where the rivets were fitted with drift pins and things of that kind. locally, the steel in the building was stressed beyond its yield points in many places. These little localized overstresses do no damage at all; the building is entirely safe. But if this building were subjected eight or ten times a day to a mild earthquake, these little localized overstresses might be nuclei from which damage would spread and eventually we would have trouble. That is, these little localized overstresses may not be important if the structure is loaded a few times but they may be of importance if the structure is loaded many thousands of times.

So far we have seen no failure that could not be explained by localized high stress, at a nick, a crack, at a point where one heat treatment stopped and another began or where there was local faulting due to that fact, possibly due to a place where there was local blue brittleness—or any one of a dozen causes. Certainly in the case of drill rods the actual distribution of stress must be different from that which any mathematical analysis could predict. It would seem that the spread of damage from the localized overstresses, so far as we can see now, explains the phenomenon known as fatigue.—Abstract of paper presented at the New York Meeting, February, 1921.

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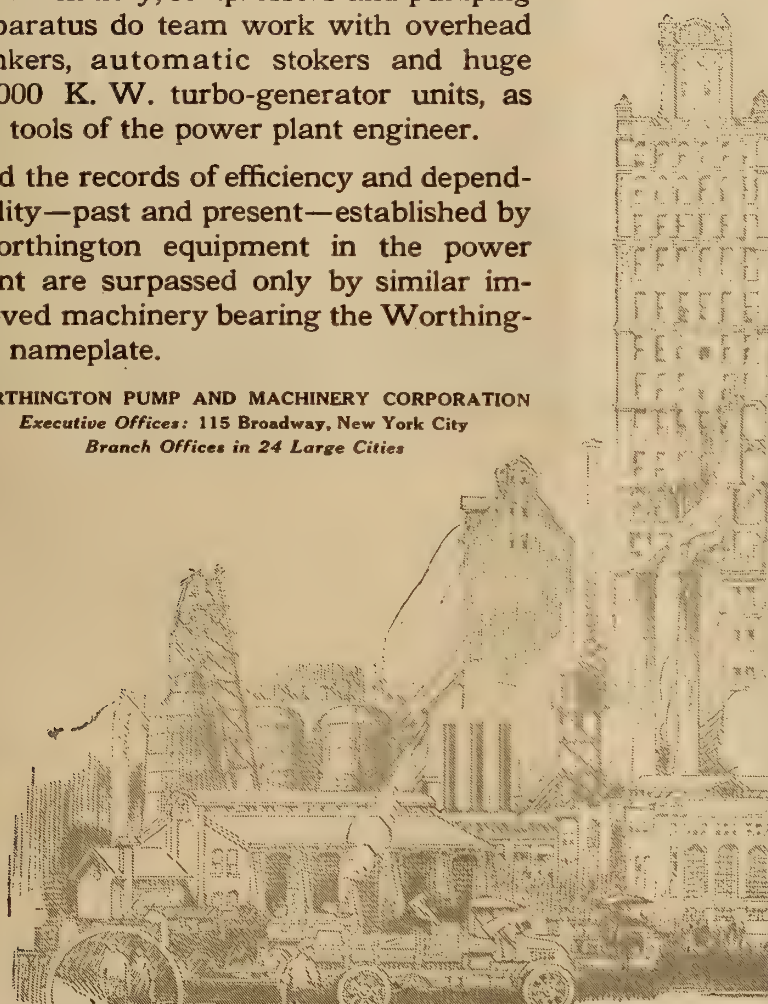

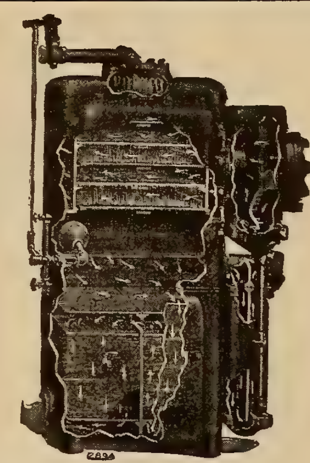

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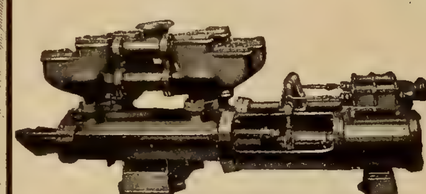
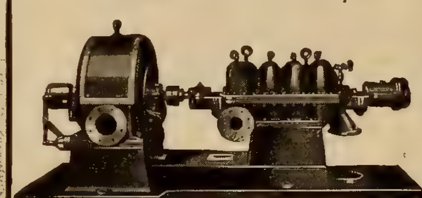


Pot Valve Boiler Feed Pump



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